Vo [illegible]

CFTRI LIBRARY
No 67
Date
MYSORE-2

186

CFTRI

DEVELOPMENT DIGEST

CFTRI LIBRARY
MYSORE-2A
- 6 APR 1976

A quarterly journal of excerpts, summaries, and reprints of current materials on economic and social development

Gordon Donald, Editor; Donna Vogt, Associate Editor;
Greta Morton, Editorial Assistant

Prepared by the NATIONAL PLANNING ASSOCIATION

for

Agency for International Development, U. S. Department of State

CONTENTS

Volume XIV | January 1976

FORESTRY

TROPICAL HARDWOOD TRADE IN THE ASIA-PACIFIC REGION 3
Kenji Takeuchi

FORESTRY MANAGEMENT AND INVESTMENT IN THE UNITED STATES 12
Arthur V. Smyth

DEVELOPMENT OF FORESTRY IN CHILE: THE ROLE OF PINUS RADIATA 14
Horacio Recart

TAX INCENTIVES FOR REFORESTATION 19
Staff of Extensao Rural

PRESERVATION OF SPECIES IN THE TROPICAL RAIN FOREST 25
A. Gómez-Pompa, C. Vázquez-Yanes, and S. Guevara

THE OTHER ENERGY CRISIS: FIREWOOD 31
Erik P. Eckholm

FARM MACHINERY

THE ECONOMICS OF FARM MECHANIZATION IN DEVELOPING COUNTRIES 39
Gordon Gemmill and Carl Eicher

VILLAGE TECHNOLOGY IN TANZANIA 48
George MacPherson and Dudley Jackson

TRACTORS AND OX PLOWS IN AFRICA 56
Uma Lele

IRRI DESIGNS OF SMALL SCALE FARM EQUIPMENT FOR DEVELOPING COUNTRY PRODUCTION 62
Carol Ulinski and Ann Becker

MOTIVATIONAL TRAINING

RESULTS OF MOTIVATIONAL TRAINING IN ECUADOR 81
James C. Frits

SARVODAYA SHRAMADANA IN SRI LANKA 87
A.T. Ariyaratne

PRICING POLICY

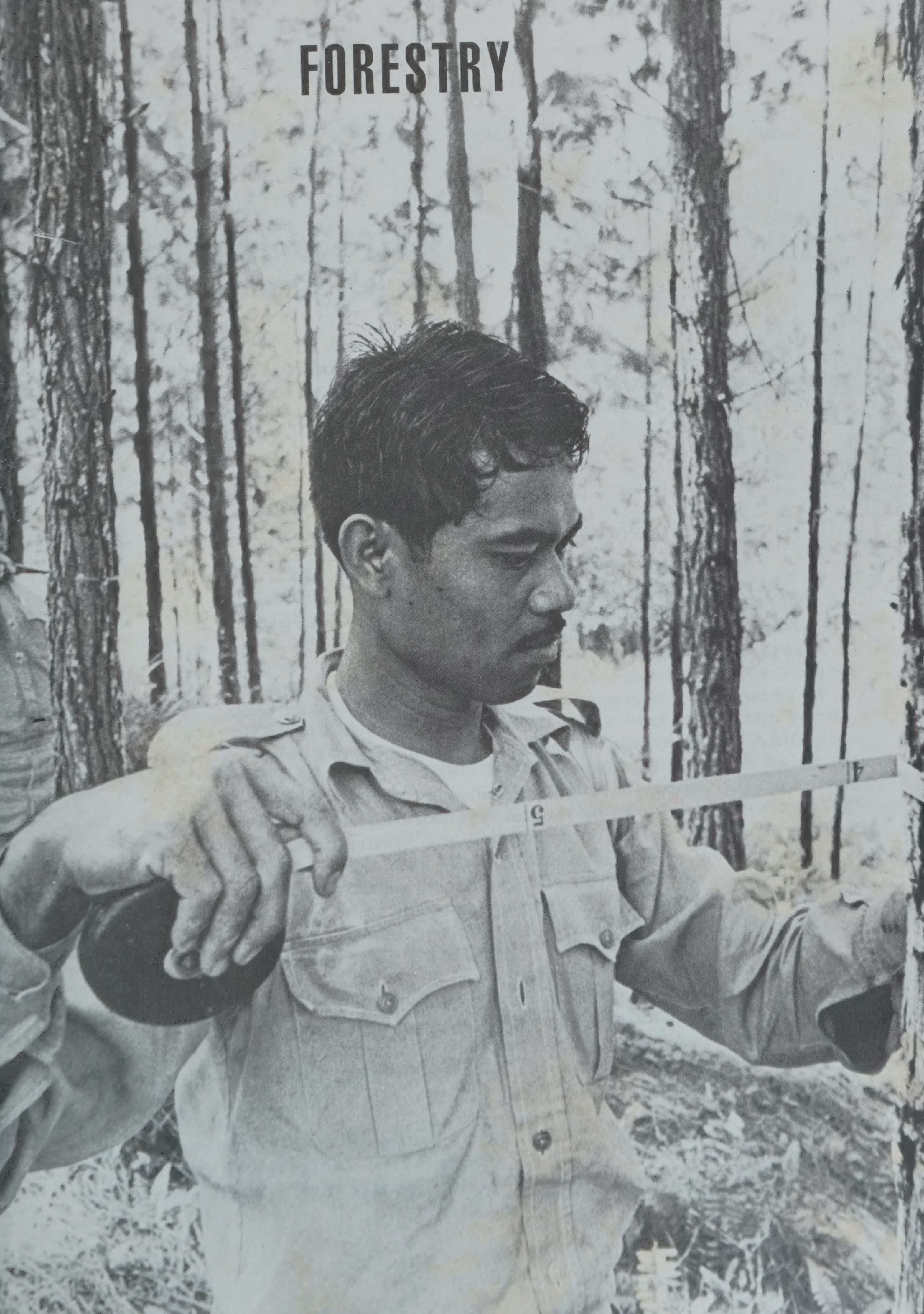
GOVERNMENT PRODUCT PRICING IN KOREA 93
Gilbert T. Brown

RICE PRICE POLICY IN THE PHILIPPINES 106
Leon A. Mears and Teresa L. Anden

FERTILIZER SUBSIDIES 113
Dana Dalrymple

(Unless otherwise indicated,
currency is expressed in U. S. dollars.)

FORESTRY



TECHNICIANS CHECK GROWTH OF BRITISH
HONDURAS PINE IN A FORESTRY RESEARCH
INSTITUTE PLANTATION, MALAYSIA
(PHOTO: UNITED NATIONS)

Tropical Hardwood Trade in the Asia-Pacific Region

Kenji Takeuchi

[Three countries in Southeast Asia supply most of the tropical hardwood products entering international trade. Methods of encouraging this production for the general development of the producing countries are outlined.]

Regional Distribution of Tropical Hardwoods and Their Export

Some 28 percent of the world's land area is occupied by forests, and about two thirds of this forested area consists of hardwood trees. Table 1 gives the distribution by continents of these areas, along with estimates of the distribution of the volume of growing stock obtained by applying estimates of the volume of wood growing per hectare in the hardwood forests of the respective continents. Among the tropical areas: Latin America has over half the world's growing stock of all hardwoods, but in terms of the production and export of tropical hardwood its share is much less than might be expected; Southeast Asia, with less than 13 percent of the world's hardwood growing stock, is the dominant producer and exporter of tropical varieties; Africa occupies an intermediate position as exporter among tropical regions (see Table 2).

Hardwood exports from Africa, mainly to Western Europe, have been growing by about 8 percent annually since the 1950s with an increasing share of the region's output destined for export. The harvesting of

Mr. Takeuchi is in the Commodities and Export Projections Division of the World Bank, Washington, D. C.

Table 1: World Distribution of Hardwood Forests

	Areas (million hectares)			Growing stock of Hardwoods	
	Total Land Area	All Forest	Hardwood Forests	billions of cubic meters	%
North America	1,875	700	260	23	9
Central America	272	71	36	3	1
South America	1,760	810	800	152	57
Africa	2,970	680	676	30	11
Europe	471	137	59	5	2
USSR	2,144	728	175	13	5
Asia	2,700	490	400	36	13
Pacific	842	88	84	5	2
World	13,034	3,704	2,490	267	100

Source: S. L. Pringle, UNASYLVA, Vol. 23, 1969 (Table 6).

Table 2: Production and Export of Tropical Hardwoods in 1968
(millions of cubic meters)

	Production	Exports		
	Logs	Logs	Processed*	Total
Tropical Latin America	16.5	0.4	0.9	1.3
Tropical Africa	12.6	6.0	2.1	8.1
Tropical Asia-Pacific	40.7	20.5	4.0	24.5
Total	69.8	26.9	7.0	33.9

*Largely sawnwood, sleepers (railroad ties), veneer sheets and plywood.

Source: FAO, Yearbook of Forest Products (annual).

species suitable for industrial use is limited, however, partly by lack of confidence of importers in unfamiliar species and partly by non-accessibility. In some areas, notably Ghana and Nigeria, almost all high forest has already been allocated on concession; but elsewhere improvements in transport facilities could greatly increase output. The Ivory Coast and Gabon are now the leading exporters.

In Latin America, much of the current timber export is of softwoods;

hardwood production and export has been relatively stagnant since the 1950s. Production of the latter is chiefly for domestic use and much of the exports move within the region — e.g. from Paraguay to Argentina. Hardwood production is limited by: a) the extremely mixed composition of tropical forests, coupled with small average size of logs; b) the extremely remote, inaccessible location of the apparently volume-rich forests, notably in Brazil and Peru, leading to high costs of exploitation.

The Asia-Pacific region is the dominant source of hardwood exports, with three Southeast Asian countries — the Philippines, Indonesia, Malaysia — accounting for two thirds of the world total in recent years. Over 70 percent of the logs exported from the "big three" goes to Japan; some of this is re-exported as plywood to the United States, but the bulk of it goes into Japanese consumption. Another 20-25 percent goes to South Korea, Taiwan and Singapore for processing and re-export — chiefly to United States and Japanese markets. Exports have been increasing quite substantially, most notably in Indonesia where they grew sharply from 1.2 million cubic meters in 1968 to over 10 million in 1970, primarily due to the logging boom in Kalimantan (sourthern Borneo). Compared to Africa or Latin America, the exports of Southeast Asia have a smaller proportion of processed wood, although their absolute magnitudes are larger in both types of export.

Prospect for Hardwood Trade In the Asia-Pacific Region

Tropical hardwood resources offer excellent opportunities for the economic development of the Asia-Pacific region. World import demand for tropical hardwood is projected to grow at 6.0 to 6.5 percent per annum (in roundwood equivalent volume) during the 1970s decade. Export earnings from tropical hardwood (including primary processed products as well as logs) of the Philippines, Malaysia, and Indonesia could potentially increase at an average rate of 11 percent to 12 percent per annum during the 1968-1980 period as a result of increased total export volume (in roundwood equivalent), increased average prices of logs, and increased value added due to greater volume of processed wood exports. This estimated growth rate compares with a growth rate of about 4 percent projected for the export earnings of developing countries from all agricultural commodities over the same period. This potential may be realized if these countries recognize their long-run interests and adopt appropriate policies.

Demand, supply and price outlook for tropical hardwood in the Asia-Pacific region. The dominant end markets for the Asia-Pacific region's tropical hardwood are Japan and the United States.

As compared to actual exports of 29.4 cubic meters in 1971, the estimated exportable volume of tropical hardwood of the Philippines, Malaysia, and Indonesia in 1975 and 1985 and the projected import are demand by Japan and the United States for the corresponding years as follows (in millions of cubic meters of unprocessed logs):

	1975	1985
Export capacity of the Philippines, Malaysia, and Indonesia	40.7	43.0
Projected total import requirements of Japan and the United States	39.0	63.0

In addition, the import demand by other countries for the tropical hardwood of the three major southeast Asian suppliers is likely to be about 4 million m^3(r) in 1975 and substantially larger in 1985. It follows that, in 1975, the Philippine, Malaysian, and Indonesian volume of exportable tropical hardwood will just about meet the needs of their two largest traditional customers as well as those of other smaller customers. It also follows that, by 1985, a large part of the increase in demand for tropical hardwood in Japan and the United States will have to be satified by trade flows from new sources because of the limited export capacity of the traditional sources, even if demand by other importing countries does not increase materially between 1975 and 1985.

From the viewpoint of Japan and the United States, the most logical potential sources of additional tropical hardwood would be Papua/New Guinea and Latin America. However, there are two basic problems concerning the forest resources in these areas: they contain a very low volume of timber per unit area (yielding only about one-third the volume per hectare found in a typical forest of the Philippines); and both of these areas have forests of quite diverse species mixture. The processing, handling and marketing problems of such a varied mixture of species are much more difficult than those of the more uniform species mixture in the Philippines, Malaysia, and Indonesia. With the added problem of a lack of infrastructural facilities, the per-unit cost of production of logs in these new areas is likely to be distinctly higher than that in the Southeast Asian producers. Therefore, prices of tropical hardwood logs are likely to move up somewhat through the mid-1970s, and they are bound to rise sharply in the period beyond, barring drastic technological improvements in the production and transportation of tropical hardwood logs that would moderate the high costs of removing massive quantities of logs from forests in Papua/New Guinea and Latin America.

An important implication of the projected long-term rise in the prices of tropical hardwood logs would be that the timber resources in the Philippines, Malaysia, and Indonesia which are located in the more accessible areas, comparatively rich in per-hectare volume and relatively uniform in species mixture, should command an increasing economic rent over time. In fact, the Philippines, Malaysia, and Indonesia combined have a virtual monopoly of relatively uniform (with respect to species), high density reserves of tropical hardwood. Since the price elasticity of demand for the combined log exports of the three countries does not seem to be high, if these three countries now jointly discourage the expansion of their exports of logs, they could earn more income per unit of logs exported in the immediate future without jeopardizing the total foreign exchange earnings from log exports, while at the same time improving their future prospects for earning foreign exchange from this source.

Wood Processing as a Vehicle of Industrial Growth

If all logs that are currently exported in log form were locally processed and then exported in the form of sawnwood, veneer, and plywood, the foreign exchange earnings from forest products in producing countries could be at least two or three times what they are now. From the viewpoint of regional development strategy, primary processing of wood — production of sawnwood, veneers, and plywood — should take place largely in the Philippines, Malaysia, and Indonesia rather than in Japan, Korea, Taiwan, and Singapore. The wood processing industry would accelerate an export-oriented industrial growth of the major log-producing countries. Economic justification for encouraging the growth of their primary wood processing industries rests mainly on the following four points.

1) Primary wood processing activities are typically weight- and volume-losing (hence freight-cost saving) activities. Converting logs to sawnwood, plywood and veneers would lose 40 percent to 60 percent of the volume and weight of log raw material. Ocean freight costs account for about one-fourth to one-third of average c. i. f. prices of tropical hardwood logs imported by Japan and Korea. Since the cost of log raw material accounts for as much as 65 percent to 80 percent of the total cost of producing sawnwood veneers and plywood, the log-producing countries should have a considerable cost advantage in primary wood processing activities over log-importing processing countries.

2) Wood processing activites (excluding pulp and paper production) are relatively labor-intensive activities.

3) Wood processing involves relatively simple technology and skill, while requiring relatively small investments in establishing factories of economic size. The Philippines, Malaysia, and Indonesia

should start with relatively simple products, while Korea, Taiwan, and Singapore should specialize in more advanced products, such as plywoods with chemical finish, various overlays, and printed face, and in secondary processing of furniture components, window frames, and door skins.

4) Wood processing activities could serve as a starter of the industrialization process in the remote areas of the outer islands — Mindanao, Sabah, Sarawak, and Kalimantan — where most of the logs that are currently exported are being produced.

Problems in the growth of processed wood exports. It has been far more profitable for the timber companies operating in the Philippines, Malaysia, and Indonesia to export logs rather than to process the wood first and then export it in processed forms because of: the tariff escalation (high tariff on processed products, low or no tariffs on unprocessed products) in the developed importing countries; the lack of opportunities in the log-producing countries to utilize wood residues economically, which would in effect reduce the cost of production of sawnwood, veneers, and plywood; the difficulties which the wood processing firms in the log-producing countries have been experiencing in obtaining necessary supplies of equipment, parts, and such essential inputs as resins (glues) for plywood production at reasonable costs; the generally low levels of technical skills of available labor in the log-producing countries; and the poor infrastructure in the log-producing countries, especially with respect to internal transportation.

Broadly speaking, tropical hardwood trade in the Asia-Pacific region involves three types of trading parties, that is, the developed importer-consumer countries (Japan, the United States, and others), the developing "in-transit" processor countries (Korea, Taiwan, and Singapore) and the log-producing developing countries (the Philippines, Malaysia, and Indonesia). These three groups of countries have had generally different types of industrial and trade policies. First was the basically "inward-looking" industrial policies of the Philippines and Indonesia; they did not help the growth of exports of processed wood products, but actually tended to penalize the exporters. Second is the decisively "outward-looking" industrial policies of Korea, Taiwan (since the mid-1960s) and Singapore (since independence) which have strongly supported the growth of export-oriented manufacturing. Third is the protectionistic policies of developed importing countries with respect to most "light manufacturing" activities, including wood processing, reflected in the "tariff escalation" of these countries. It is the combination of these different types of industrial and trade policies of the major parties involved that has strongly conditioned the pattern of tropical hardwood trade in the Asia-Pacific region.

A strategy for accelerating the growth of processed wood exports. In recent years the Philippines and Indonesia have changed their industrial and trade policies from being markedly inward-looking to generally outward-looking. To assure a decisive success in their processed wood exports, their outward-looking policies will probably have to be developed even further. Partly due to the early and decisive change of policy in this regard, West Malaysia is now exporting two-thirds of its wood in processed form, mainly sawnwood.

The three major log-exporting countries could encourage wood processing at home by: discouraging the export of logs by jointly maintaining substantial export taxes; encouraging the growth of export-oriented wood processing industries by providing comprehensive "packages" of incentives; adjusting their forestry concession policies so as to discourage exports of logs and encourage exports of processed products; and improving infrastructure to induce rapid growth of export-oriented wood processing industries. In implementing these policies, integrated companies could handle all steps from the resource through processing, shipping, distribution, and even application in end use. Or an integration could be effectively achieved by contractual arrangements, partial integration, and joint ventures. The ideal industrial structure would be one that has deep penetration in a variety of market sectors but is not concentrated enough to exercise monopoly control of the resource and processing industry, and has a vested interest in maximizing processing and species utilization.

Joint actions to discourage log exports would be of mutual benefit to the three log-exporting countries. For instance, if the Philippines and Malaysia alone would restrict log exports but Indonesia would not, then Indonesian logs would fill most, if not all, of the trade volume now moving in log form. The result would be that the newly developing wood processing industries in the Philippines and Malaysia would suffer in competing with the established industries of the traditional log-importing countries. Regional cooperation is clearly in the long-term interest of the countries involved.

Would the exporters of logs not lose in terms of total foreign exchange earnings from that commodity because, although they will get a higher average price per unit, they will be selling less volume than otherwise? Unfortunately, no reliable estimate of the price elasticity of demand for the log exports of these countries is available. However, the demand for tropical hardwood in general is probably price-inelastic because the demand for processed products made from tropical hardwood is generally inelastic. Domestic supply of the closest substitute, temperate hardwood in the importing countries, is quite inelastic; softwoods and nonwood materials are good substitutes only in limited end uses. The cost of getting tropical hardwood logs in great quantities from alternative sources such as Indochina, the southwest Pacific islands, and Latin America would be much higher than the existing conditions because of political uncertainties (Indochina), higher freight costs (Latin America), and generally higher cost of production. Competition with Africa in the European market might increase demand elasticity if the African supplies could be increased faster than demand; but this has been a small market for Southeast Asia. Thus, the price elasticity of demand for log exports of the three major Asian exporters is probably less than unity; by acting jointly to discourage log exports, the Philippines, Malaysia, and Indonesia would not lose foreign exchange earnings from logs, while they will have much to gain if the measure contributes toward accelerating their exports of processed products.

It would be advantageous for the three countries to cooperate closely in setting the levels of export taxes, and coordinating national policies on export incentives for processed products and forestry concessions. They can also benefit from consultations on matters of infrastructure involving shipping and stocking. Already, some international cooperation exists among the log-producing countries. In 1969, the Philippines and Indonesia concluded eight agreements on economic and technical cooperation, two of which bear directly upon forestry and forest industries. Through the Association of Southeast Asian Nations (ASEAN), membership in which includes Indonesia, Malaysia, the Philippines, as well as Singapore and Thailand, economic and trade cooperation on timber processing, among others, is being studied.

It should be in the interest of the United States, Japan, and other importers of tropical hardwood, as well as in the interest of the less developed countries, if these developed nations adjusted their policies to anticipate the long-term trends in development of the industry and to facilitate the adjustments needed by a significant reduction of import duties on the processed tropical hardwood coming from less developed countries. In the meantime, Japanese plywood manufacturers should probably specialize in sophisticated products, for example, plywoods with printed face, chemical and other special finishes and various overlays, and products of exceptionally high standards of fire-resistance. They may aim at diversifying themselves vertically, for instance, into the prefabricated housing industry. Finally, the in-transit processor countries — principally Korea, Taiwan, and Singapore — should gradually grow out of the reliance on the export of plain primary processed products. In the cases of Korea and Taiwan, plywood exports are contributing very little in the way of net foreign exchange earnings as a result of excessively generous incentives for export. It seems to be in the long-run interest of these processor countries to move toward specialization in the exports of wood products involving a higher value added and larger net foreign exchange earnings in so-called secondary processing, that is, prefinished plywood, furniture components, and so forth.

A Long-Term Forestry Policy

World demand for tropical hardwood is expected to continue its rapid growth for at least another decade and, quite possibly, much longer. In the meantime, as a result of the rapid growth of export demand for timber, some of the traditional sources of supply in the region, such as the Philippines and West Malaysia, are being threatened with possible depletion of timber resources in the near future. The experience of the Philippines and, to some extent, that of Sabah and Sarawak, indicates a wasteful use of timber resources due to poor and shortsighted logging practices and a lack of adequate forest management. Indonesia, at the moment, boasts "unlimited" forest resources, but will have to face the problem of depletion eventually and would be well advised to take appropriate measures to avoid wasteful use of its resources as soon as possible, and to maximize the long-run benefits for the nation's economy.

One possibility to alleviate the depletion threats in the forest resources of the Philippines, Malaysia, and Indonesia is fast-growing forest plantations. Man-made forests are growing in importance as sources of industrial wood around the world. Demand for paper and hence for wood material for paper-making is growing fast in the developing countries as well as in the rest of the world. It is highly desirable for developing countries to be able to meet their growing paper needs themselves at competitive costs. Although the hardwoods they do possess in natural forests are increasingly used for pulping, at present the bulk of the grades supplied through the trade are made from long-fiber softwoods. Long-fiber softwoods occur indigenously only in limited quantities and limited areas in the tropical countries. But there are vast areas in the Southeast Asian countries where exotic softwoods and pulpable hardwoods could be grown in man-made forests. The possibilities of forest plantations using a few fast-growing species in the Philippines, Malaysia, and Indonesia should be studied. These plantations could provide additional low-cost wood material for pulp and paper and other forest industries in the three countries in the long run.

[Extracted from Tropical Hard-Wood Trade in the Asia-Pacific Region, Chapters 1 and 3, World Bank Occasional Papers No. 17, 1974, Copyright ©, International Bank for Reconstruction and Development.]

Forestry Management and Investment in the United States

Arthur V. Smyth

[The unique nature of wood as a renewable natural resource and the increasing world demand for wood fiber has encouraged intensive management of American forests. This article describes very briefly some of the advanced forestry management practices of one of the leading timber companies.]

In the early days of the U. S. forest products industry timber was so abundant that it had a relatively low value. Consequently, the resource was used wastefully for many years, and investments in tree planting were not financially rewarding. But as the virgin timber gradually became scarcer, and also more valuable as markets opened up, investments in growing timber became more feasible. In the Southern pine region, a technological breakthrough around 1910 in the kraft pulp and paper industry resulted in the construction of large capital-intensive mills which demanded an assurance of a continuing supply of raw material. The first serious attempts to grow timber commercially began in the South; by the 1920s the last virgin stands of southern pine had been cut. In the far West the old-growth forests on private industrial lands will last another 20 - 25 years. Here, increasing world demand has made intensive forest management practices profitable.

Mr. Smyth is a Vice President of Weyerhaeuser Company, a leading American timber company.

Since World War II there has been a rapid growth in demand for wood products, both in the U. S. and still more in Japan and Europe. The industry is highly competitive, and also extremely cyclical in its price movements, but the overall market trend is strongly upward. This is expected to continue for the many years ahead that are involved in making investment plans for a product with such a long period of gestation. Douglas fir, for example, reach commercial cutting size on a average of 50 years of age -- 40 years in ideal land and growing conditions. To cash in on this booming market, more wood must be grown per acre, and more parts of the tree utilized than before. Research and improved practices are creating great advances in both fields.

The Weyerhaeuser Company utilizes an elaborate computer program for guiding the management of its very large and complex forest investments. The basis of the computer model is tree biology, combined with forestry and processing costs, with an expanding market assumed. The program indicated that forestry management applied to Douglas fir in the western states can be profitable using the following practices. (1) Complete replanting within 12 months after cutting, using 2 - 3 year seedlings from company nurseries. (2) Precommercial thinning after 15 years, removing trees which will be overshadowed and growth-inhibited by taller trees of better quality. (3) Apply nitrogen fertilizer by helicopter, once the non-desired trees are removed. (Ground application to desired trees is too costly in the vast mountainous areas of the U. S., though it may be practical elsewhere.) (4) Commercial thinning. (5) Clear-cutting and replanting after 40 - 50 years, utilizing all the wood possible from each acre; previously almost half the volume of logging was left on the ground as slash. (6) Genetic stock improvement: the Company maintains breeding nurseries for selecting seeds of trees with superior yields of wood. By now, a forest so managed produces 1.9 times per acre the value of an unmanaged forest, and further gains are likely.

(Adapted from a speech to the
National Economists Club,
Washington, D. C., November
6, 1975.)

Development of Forestry in Chile: The Role of Pinus Radiata

Horacio Recart

[The general development of forestry in Chile, and the successful plantation and exploitation of the Monterey pine species, are described.]

Chile has been called a country with a "crazy geography." On the map it appears as a 3,000 mile long but narrow strip of land squeezed between the mountains and the sea, stretching from the hot desert of the north to the cold lands of the extreme south. The natural forests, largely in the rainy middle-south, cover about 13 million hectares; 5 million are considered commercial. In addition, there are about 320,000 hectares of plantations of exotic species, 95 percent of which is Monterey Pine (Pinus radiata). When the Spanish conquerors came 400 years ago, a much greater part of the territory probably was covered with forests, but in more recent times, the forests have diminished through lack of adequate protection. Chile has not adopted a definite forest policy nor a proper state administration. The results are too well known: indiscriminate and destructive exploitation, scant utilization of the trees, and heavy burning to clear the land. On the contrary, the government has always given preferential attention to agricultural development, disregarding the principle sustained by foresters and conservationists that no sound agriculture can exist without sound forestry.

Dr. Recart is retired chief, Lumber
Division, Corporacion de Fomento de
la Produccion, Santiago, Chile.

Six outstanding events have marked the development of Chilean forestry since 1930.

Forest legislation. The forest law of 1931 gave the first impulse to forest plantations. It exempted the land and forest from taxation for a period of 30 years and granted a bonus per hectare planted. A 1951 law offered further incentives, exempting plantations from payment of income taxes and inheritance duties. The 1966 Law of Agrarian Reform stipulates that all plantations established in forest soils cannot be expropriated, no matter what their size might be. This security is vital; 90 percent of plantations and 100 percent of the pine industries are in private ownership.

The Chilean Development Corporation. This government agency, entrusted with the industrial development of the country, decided in 1942 to include forestry in its development programs by creating a special section for the study and preparation of forestry projects. This step meant formal recognition of the importance of forestry in the national economy and the potential value of the forest resources. The Corporation created a line of special credits to foster plantations and expansion of forest industries, and this agency has proved to be a leading, driving force in forestry development.

Study of the forest resources. But the lack of sound resource information was a serious impediment for constructive planning. A technical mission of the U. S. Forest Service, headed by I. T. Haig, came to Chile in 1944. The mission made a physical and economic study, including forest inventory, forest depletion, forest growth, timber requirements, forest industries and forest policy. The information and recommendations of the mission's report have continued to serve as a solid basis and guidance in matters of forest policy and in the planning of development programs.

Assistance in development projects. The principal source of technical assistance in forestry has been the Food and Agriculture Organization of the United Nations (FAO). FAO has undertaken numerous study projects covering practically all fields of forestry and provided a number of technicians. FAO also plays an important role in awakening a forestry conscience, particularly among state authorities, prompting them to take action in forestry matters. Several countries, mainly in Europe and North America, signed agreements with the Chilean government to supply technical advice on specific projects, scholarships, machinery, equipment and other facilities.

Forestry education. Chile for some time recognized that the training of forestry engineers at university level was fundamental for proper management of the forest resources and industries. As the demand for such professionals increased, the government decided to create a Forestry School at the University of Chile in Santiago in 1952. Two years later a second School of Forestry came to life at the Universidad Austral in the city of Valdivia. The forestry profession is now firmly established in Chile and graduates from both schools are engaged in practically all phases of forestry. The total number of graduate foresters is now around 140 and almost all of them are members of the Chilean Forestry Association, founded in 1960. At the vocational level, two specialized schools have been established: one at the Technical State University in Concepción for the training of technicians in wood machinery and auxiliary equipment; the other for forest rangers, under the University of Concepción in Los Angeles. Both of them are entirely staffed by Chilean personnel.

The Forestry Institute. The Forest Institute was established by the Chilean government in 1962 to carry out applied research in the fields of silviculture, wood technology and economics; to develop forest industries through specific working projects; and to give skilled training to personnel working in forest enterprises by means of short courses, field demonstrations and scholarships.

The Role of Monterey Pine

The Monterey Pine, called "Pino Insigne" in Chile, was first introduced in 1886 when the first seeds were imported from the U. S. by a group of landowners in the Concepción area. Their object was to establish plantations for the sole purpose of protecting degraded lands. From the start, the rapid growth and adaptability to poor soils of this new species were surprising. It is estimated that in 1925 there were no less than 5,000 hectares in the provinces of Concepción and Arauco alone. The first formal inventory taken by the Development Corporation in 1952 gave a total of 186,000 hectares. This inventory helped to change the existing attitude toward plantations, making people realize their considerable potential value. A 1970 inventory by the Forestry Institute showed a planted area of 300,741 hectares with a volume of 64,410,000 cubic meters. The total annual yield was estimated in 4 million cubic meters. The yearly planting reached 15,824 hectares during the period 1966-1970.

Lumber. Until 1925 lumber production was confined to the native woods. Around 12 commercial species amply satisfied national requirements, leaving a small excess for export. The first appearance of pine lumber in 1925 found no market, as it was considered of too inferior quality. The first successful marketing of pine was in the form of box shooks for containers; pine proved superior to native woods for this use because of low weight and ease of drying, which facilitated nailing. Gradually Pinus radiata won acceptance. In 1940, when total lumber production was 220,000 Mbf (thousand board feet) pine contributed only 10,000 — less than 5 percent of the total. But in 1970 the picture was quite different: out of a total production of 419,000 Mbf, pine had an output of nearly 234,000 Mbf, or 56 percent. *Pinus radiata* had surpassed the native woods, boosting production 23 times in 30 years. This spectacular increase may be attributed to the many uses found for pine lumber in rural housing, interior finishing, exterior siding, boxes and furniture. But a great part of the credit goes to better manufacture made possible by modern machinery and equipment for drying and stain treatment. Pine lumber is also gradually finding its way into foreign markets, and in 1970, 56 percent of the total lumber exported was pine.

Pulp and paper. Chile depended in the past almost entirely on foreign sources for pulp and paper. But with the growth of pine plantations, the installation of new plants has given Chile the leadership in pulp manufacture in Latin America. In 1966-1970 pulp production reached 300,400 metric tons per year, leaving a surplus of 96,300 tons for export. The average annual production of newsprint and other papers during the same period reached 242,800 tons, covering the country's consumption and leaving 81,300 tons for export. Thus, in 30 years pulp production has increased 24 times and papers and cardboards over seven times.

Fiber board and particle board. Fiber board did not exist in Chile as a national product until 1959. Before then, the only particle boards produced in the country were of plywood from native woods, and production had remained stationary. There was a real need for a new product, and with *Pinus radiata* being an excellent raw material and available in appreciable quantities, the fiberboard industry came to life in 1959. The plant started with a production of about 50,000 metric tons per year and in 1970 had reached 16,700 tons. Production during the period 1966-1970 attained 13,000 tons per year. Both types of board are consumed mostly within the country.

The general welfare. *Pinus radiata* has contributed to the general welfare in employment and regional development. The plantations and tributary industries have opened important sources of permanent employment, permitting the stabilization of the labor force, providing better living conditions in adjacent areas, thus diminishing the traditional migration to urban centers. The application of advanced techniques in the operation of modern machinery, tools and equipment, has opened a wide field for skilled workers and technicians who can be trained through field practice and in the two existing vocational schools. Finally, the plantations and pine industries offer forest engineers attractive opportunities for employment.

Many changes contributing to development of extensive rural areas tributary to the industrial centers have stemmed from establishment of forest industries. The indispensable structural changes, such as new roads, power lines, communications and auxiliary services, have brought new life to many regions and have signified permanent progress, especially to those distant from urban centers. In the social aspect, the populations established in those areas are usually offered satisfactory living conditions in the form of new houses, shopping facilities, recreation centers, schools, hospitals and other services.

The pine industries represented in 1970 a total investment of nearly $200,000,000 with an average annual production for the period 1966-1970 amounting to $106,600,000. Yearly exports during the same period had an export value of $26,000,000. Pulp and paper represented 85 percent of total investments among the pine industries, 82 percent of total production and 93 percent of total exports. Thus, the role of Pinus radiata in the development of Chilean forestry has been revolutionary. A tree species of little importance in its native habitat, planted in a relatively small area and reaching maturity in 25 years, has created a considerable wealth in a foreign land. The experience of Chile will be, no doubt, of interest to many countries with possibilities of establishing plantations of exotic species. Chile may look to the future with optimism: the country still has 20 million hectares of land waiting to be planted.

[Extracted from Journal of Forestry,
Vol. 71, July 1973, pp. 407-411.
Copyright ©, The Society of America
Forestry, Washington, D. C.]

Tax Incentives for Reforestation

Staff of Extensão Rural

[The devastation of Brazilian forests proceeded unchecked for many years, with no plans for their rational replacement. In 1966 and 1970 the Brazilian government enacted laws permitting deductions in income taxes for investments in forestry projects. In less than five years these tax laws have resulted in 5, 228 approved projects for the planting of 1. 8 billion trees in an area of over 820, 000 hectares.]

Brazil has today 352. 3 million hectares of forest land, about 41% of its total territory of which 273. 1 million hectares are found in the northern Amazon region. Only 93 million hectares of forest are considered accessible to economical industrial uses, and approximately 40 million are currently being exploited. There are four major types of forest:

1) Equatorial Hygrophytic Forests — These heterogeneous forests, with as many as 100 different varieties of trees in one hectare, are located in the Amazon basin and near the coast line. The amount of timber growing in these forests may be as much as 300 cubic meters per hectare, but only a very small quantity will be of commercial value. The most common species found in these forests are the cedar, caoba, and laurel.

2) Deciduous Forests of Humid Climate — Initially this kind of forest covered extensive areas of

Extensao Rural is the monthly journal of the Brazilian Association for Rural Credit and Assistance — ABCAR. The article was translated for the Development Digest by Alcione Amos.

Brazilian soil in the southern and eastern states and small areas in the northeast and north. But because they occupied regions which were good for agriculture, they were widely eliminated. The remaining forests are now located in small areas; these can yield about 200 or 300 cubic meters of timber per hectare. The most common species found in these forests are the jacarandá (rosewood), peroba, guarantan and cedar: all of these have great commercial value.

3) Xerophytic Forests — These are typical of the dry areas in the Northeast. The trees are of small size, with distorted conformation and the wood is of bad quality. They are used almost exclusively for fire wood.

4) Forests of the Warm-Temperate Climate — These are Brazil's most important forest reserves because they include large areas of pines (Araucária angustifólia) located in the southern states. The pine is used as raw material for the production of paper, cardboard, and cellulose.

Until recently these four types of forests were being systematically destroyed. Sepcies of great commercial value located near consumer and export centers were cut down with no concern for replacements. For example, studies by the Ministry of Agriculture revealed that the exploitation of pine reached an annual peak of 250,000 hectares. The same studies concluded that if this rate of exploitation was maintained, it would lead to the total extinction of the species in 10 years. Engineer David Azembuja, a professor at the Federal Rural University of Rio de Janeiro, declared in his work Project for the Development and Research of Forests that the development of Brazilian forests has been limited for many years as a result of three main factors:

1) Lack of species which were economially feasible for the restoration of the forests. Although the fast-growing eucalyptus was found to be the best solution for the demand of timber in many uses, it was evident that one species alone could not entirely satisfy the demand. It was necessary to find new adaptable species which would fill the demands of the various uses of wood which grow day by day with the industrial development of the country. By 1955 the first coniferous trees began to be cultivated in Sao Paulo. They grew fast and were good for many uses. After less than 10 years of cultivation, it was already possible to see that the conifers were a new option for forest restoration. Various different types of the species have already been successfully cultivated: Pinus elliotti, Pinus taeda, Pinus caribae, Pinus oocarpa, Pinus patula, etc.

2) The small number of forestry specialists in the country contributed to the problem. It was only after the creation of the first forestry school in Brazil in 1960, and the subsequent establishment of other

schools in the same field, that the country had available a larger number of professionals and technicians in forestry. Today 70 forestry specialists graduate every year from four regional forestry schools, and two universities are starting new forestry schools.

3) The lack of economic incentives which would allow the forestry industry to develop its activities on a self-sustaining basis. For many years the lack of economic resources had restricted the development of forestry enterprises in Brazil.

This situation changed after 1964. At that time the government, alerted to the great danger to which our forests were exposed, began to give more attention to the urgent need for action in support of forestry. Studies dating from 1961 had shown that the utilization of timber in Brazil was equivalent to approximately 300 million trees cut down annually, while the restoration of the forests was practically non-existent. To give an estimate of the deficiency in restoration: up to 1966 the total area of forests which had been restored in Brazil did not exceed 600,000 hectares; of these, 400,000 were located in only one state — Sao Paulo.

Income Tax Incentives

The Federal government understood that a simple law ordering the restoration of forests and the conservation of the natural resources of the country was not the most practical solution for the problem. Trees would not be planted in sufficient numbers unless the necessary economic support and infrastructure were offered. It was in thinking about these needs that the authorities decided to create a package of income tax incentives with the objective of implementing the country's forestry development.

The first measure tried to stimulate the interest of the rural landowner in the restoration of forests. The new Forestry Code (Law No. 4,771/65) allowed the exemption of rural territorial tax for land used to plant forests for commercial exploration of the timber. Investors were also allowed to deduct from their income tax sums which had been invested in forest renovation projects. Nevertheless, the results were not significant. The government, then looking for more effective solutions to the problem, enacted a series of laws, and devised a new policy of income tax incentives for forestry development projects. The bases for this new policy were Law No. 5,106 in 1966 and Decree Law No. 1,134 in 1970.

The income tax incentives are offered to the taxpayer in two forms. The first, established by Law No. 5,106, allows the taxpayer, either an individual or corporation, to make an investment prior to the time of his income tax return, and he may then deduct from his gross income those sums which he can prove were invested in forestry development projects, up to 50% of the tax he owes. Law No. 5,106 allows for two types of projects. The "individual project" demands only one participant, who implements the project directly or through a specialized corporation. This kind of project could last for one year or longer, but at least 10,000 trees must be planted to qualify the project for the income tax deduction. Usually paper mills, timber and cellulose industries, and steel industries have taken advantage of this kind of project. The other type of project, known as the "multiple project," is always implemented under the orientation of technical corporations connected with forestry developments. There are now 430 of these corporations registered with the Brazilian Institute for Forestry Development (IBDF).

The second option for income tax deduction, established by Decree Law 1,134 for the exclusive use of corporations, allows the company to earmark 50% of its tax for investment in forestry development projects which have been authorized by the IBDF. It added a new feature to the previously offered incentives in that the taxpayer has the possibility of investing in forestry projects initiated by a third party, while before only the taxpayers who were landowners could take advantage of the incentives. The kind of forestry development projects approved by the IBDF are those which relate to the industrial exploitation of timber, the conservation of soil, or the conservation of water resources. Law No. 1,134 includes two types of participation: in projects with public corporations (of anonymous ownership) the investor participates in the project by buying the corporation's shares. In the other type of project, which are essentially partnerships, the investor receives "participation certificates" in forestry restoration projects.

The decrees regulating the forestry development projects also specify that no project will be approved if it does not include the planting of at least 1% of species which are typical of the area and are economially valuable, or if 10% of the natural forest of that particular area is not preserved. The conservation projects may include different tree species, such as fruit trees or larger species. The areas in which these projects are being developed remain under the supervision of the IBDF in every aspect of their exploitation. The owners of such areas are requested to maintain a register of all the alterations which develop from the exploitation of the forest, including the restoration of the forest, the use of the area for other projects, or the extinction of the forest for natural reasons.

Results of the Tax Incentives

The new policy of the government offering tax incentives to the taxpayer has proved its effectiveness. Taxpayers learning that the investment in forestry restoration projects will bring them profits in a short period of time have answered the government's appeal and invested their money. Statistics compiled by the IBDF reveal that the investment grew steadily. Since August 1967 about 7,100 investors have taken advantage of the new tax law incentives. As of January 1972, 5,228 projects had been approved for the planting of 1.8 billion trees. These trees were planted in an area of over 820,000 hectares, and represented an investment of more than 1.2 billion cruzeiros. Projects are found in 12 states, largely in the southern parts of Brazil. In Sao Paulo 2467 projects have planted 577 million trees, an investment of 400 million cruzeiros; in Paraná, 1097 projects have planted 441 million trees at a cost of 270 million cruzeiros; and Minas Gerais, with 672 projects, has spent 250 million cruzeiros to plant 410 million trees.

Future Perspectives

The government's attention to the execution of projects which will bring growth to the timber industry are part of its general policy to stimulate the production of commodities in great demand by external markets, such as soybeans, corn, meats, and fish. The forestry projects being implemented now are primarily using the Paraná pine (Araucária angustifólia) and the American pine (Pinus elliotti or Pinus taeda) for reforestation. It is estimated that there will be in the southern part of the country a large production capacity which might permit an annual output of 1.5 million cubic meters of timber by 1975. This amount would be sufficient to manufacture 300,000 tons of the long fiber cellulose — this figure is almost equivalent to 50% of the national production of cellulose for 1970.

Mr. Golfari, FAO's technical advisor working with the IBDF, also estimates that to achieve self sufficiency in the industrial utilization of timber, keeping in mind the increase in population and consumer needs, Brazil will have to restore its forests by a minimum of 2 million hectares. If this objective is achieved, the excellent conditions of soil and climate in the regions where the projects are being developed could guarantee the continuity of timber production. The forests planted with pines and eucalyptus show an annual increase of 20 cubic meters per hectare in Brazil. This figure compares favorably to the United States, where annual production reaches 12 cubic meters per hectare, in France 7.5 cubic meters and in Spain 3.5 cubic meters. The waiting period necessary before the felling of such trees is 7 years in Brazil, while the average period in the United States for commercial trees is 12 years, and in France, Norway and Sweden the waiting period is 25 years.

Besides all these favorable factors, Brazil has large areas which are capable of being used for new projects, thus assuring continuity for the development of forest restoration. In the southern region alone, from Sao Paulo to Rio Grande do Sul, about 16 million hectares, or 20% of the area, are considered suitable for use in forestry development projects. The lumber production offered by these lands will be sufficient to meet the internal demand and part of the external demand. Regarding external markets we must mention in particular the European market, for which the deficit of timber products will reach an estimated 70 million cubic meters in 1975. Mr. Golfari states that: "Brazil has the potential to supply this demand within a few decades, exporting its excess production of timber obtained from restored forests in products such as chips, cellulose, board, and sawn lumber. Timber products might become the country's largest export in the future."

[Extracted from "Os Frutos do Reflorestamento," Extensao Rural, Vol. VI, No. 76, April 1972, pp. 3-8. Rio de Janeiro: Associacao Brasileira de Crédito e Assistencia Rural.]

Preservation of Species and the Tropical Rain Forest

A. Gómez-Pompa, C. Vázquez-Yanes,
and S. Guevara

[Indiscriminate cutting of tropical rain forests could in time bring about a permanent loss of tree species now known to be valuable, along with a loss of many species whose qualities have not yet been tested scientifically and whose value might also be considerable. This is due to the very complex mixtures of species found in such forests (e. g. in Malaysia, research revealed 227 species over 4 inches in diameter on only 2. 5 acres) and the great variety in local ecosystems.]

During the last few million years of their evolution, the tropical rain forests of the world have produced their own regeneration system through the process of secondary forest succession. This regeneration system evolved in the many clearings that occurred naturally as a result of river floods, storms, and trees that die of age. The genetic pool available for recolonization of these spaces was great, and a number of populations and species with characteristics that were advantageous in the recolonization of such breaks in the continuity of the primary rain forests were selected. These plants were fast growing heliophytes, with seeds which have dormancy and long viability, and efficient dispersal mechanisms. Little is known about their biology, their behavior in the succession, and their evolution. But the few works on the subject point out that there are certain repetitive patterns that can be predicted and that the secondary species involved are fundamentally different from the primary species.

The authors are in the department of botany at the Institute of Biology, National University of Mexico, Mexico City.

One of the most important aspects of natural regeneration is that on the floor of the primary rain forest there are always seedlings of young plants of many of the primary tree species. Under the effects of disturbance these seedlings will continue growing at an increased rate, while the secondary species also start growth from dormant seeds in the soil. After several years the primary species will have grown taller than the secondary ones, and the former will take over the upper canopy of the old successional series. Another important means of regeneration comes from seeds in the soil. In tropical rain forests this type of regeneration seems to be very effective mainly for species that happen to be in fruit during the disturbance of the area, because apparently there is a very short dormancy of the seeds of most of the primary species and the entire life of seeds of tropical tree species is in many cases very short.

The many, and quite different primary tree species in the rain forests of the world may behave very differently in their germination responses and life-span. The available evidence indicates, nevertheless, that many primary tree species have large seeds with either short dormancy or none at all. The general trend is toward rapid germination, which is usually advantageous to the survival of the species. If one considers the predators of all types (fungi, bacteria, animals of various types) that are present in tropical warm and humid conditions, it seems reasonable to attribute survival power to species the seeds of which can germinate quickly, and the seedlings of which can remain alive for a long time in a slow-growing condition. Another possibility for the establishment of primary tree species in the early stages of regeneration is by long-distance dispersal by birds and by animals such as monkeys, rodents, and others. This process is playing an important role in areas where human distrubance has not reached a critical level, but very little research has been done on dispersal characteristics. Still another means of reestablishment of primary species in the early stages of succession is vegetative reproduction by means of rhizomes, bulbs, and roots that may remain alive after the destruction of the original forest and become active soon after the disruption.

Shifting Cultivation

In addition to regeneration following natural catastrophes, the regenerative system of the rain forest seems also to be well adapted to the activities of primitive man. The use of small pieces of land for agriculture, and their abandonment after the decrease of crop production (shifting agriculture), is similar to the occasional destruction of the forest by natural causes. Shifting agriculture has been a natural way to use the regenerative properties of the rain forest for the benefit of man. After the abandonment of the land by the primitive farmer, regeneration starts with the available seeds and other propagules in the soil. The seeds now known to remain viable in the soil are mainly those of secondary species, so most of the future propagules of primary trees have to come in by natural dispersal (such as animals, water, gravity, or air). The speed of regeneration under these circumstances is a problem, but in general one can say that under the shifting cultivation system, the genetic pool of primary trees is retained, and from this pool comes the raw material for the successional processes. Of course, this is true only where demographic pressure has not forced an intensive shifting agriculture with only short periods of recovery between cultivations.

The Tropical Rain Forest In The Era Of Intensive Cultivation

Permanent use of land in tropical areas now can be accomplished with the help of new technology and chemicals. These methods have opened greater possibilities for making available large extents of land for agricultural crops; the new trends can be seen in almost any tropical area today. Under an intensive and extensive use of the land, sources of seeds of primary tree species for regeneration become less and less available because of the dispersal characteristics of those species, and because of the scarcity of individuals of most of the tree species. The only species available that are preadapted for continuous disturbance are secondary species, or primary species with some of the characteristics of the secondary ones. This group of species has characteristics that enable them to thrive in such conditions; they produce large numbers of seeds, which have means of long-distance dispersal and dormancy; these seeds accumulate and stay alive in the soil (that is, they have a long life-span). The process often called "savannization" of the tropical humid regions can very well be explained by these characteristics; this process may well account for many of the low semi-evergreen selvas and the savanna woodlands in Mexico, as well as similar areas in Asia, Africa and South America. Also, plants preadapted for disturbance, such as ones from drier environments with built-in adaptations to remain alive in a dormant condition for long periods of time, may invade these areas and allow them to regenerate a forest vegetation. An ecosystem consisting of secondary species mixed with species from drier environments will become established. Since these species are generally lower in stature at maturity, the vegetation will also be lower in stature than the one the climate could allow.

Implications

With the present rate of destruction of the tropical rain forests throughout the world, there is great danger of mass extinction of thousands of species. This is because primary tree species from the tropical rain forests are incapable of recolonizing large areas once these have been opened to intensive and extensive agriculture. It has been argued that countries like those of Europe, the United States, and Japan have used the land intensively and extensively, and there is not much evidence of mass disappearance of species. In temperate areas, however, the primary tree species are in many cases represented by a great number of individuals, and the distribution of many of the temperate species is large. In addition, many of them possess seeds adapted to long periods of inactivity, thereby conserving their vitality (dormancy and long life-span) for periods of time while buried in the soil. Even though there are no reliable records of the life-span of seeds of trees buried in the soil of temperate regions, the available data known to us suggest strongly the possibility that seeds stored in soils long retain their potential for growth. All these aspects yield a very different general behavior of the land cleared for agriculture and its possible future regeneration. It is important to note that an isolated tree from a primary temperate forest has greater probability of survival than an isolated tree from a tropical rain forest; this is due to the complex and delicate net of relationships of each individual with that environment. This means that a gene pool of primary trees can be maintained along roads, near houses, and the like, for temperate areas but not for the tropical rain forest. If we add to these ideas the great difference in number of national parks, arboreta, botanic gardens, and storage facilities in many temperate areas, in contrast with the virtual absence of such resources in the tropics, the problem grows to a more critical dimension.

All of the above is applicable to tropical evergreen rain forests in the warm and humid areas of the world. In drier tropical areas with a definite long dry season the problem is very different, and the plants behave in connection with the problems of regeneration under intensive exploitation in a manner more similar to those of temperate areas. The reason for this is that these plants are in some ways preadapted to great disturbances since they possess better characteristics for survival during periods of adverse conditions (drought, fire).

All the evidence available supports the idea that, under present intensive use of the land in tropical rain forest regions, the ecosystems are in danger of a mass extinction of many of their species. This has already happened in several areas of the tropical world, and in the near future it may be of even greater intensity. Thousands of species could disappear before any aspect of their biology has been investigated. This would mean the loss of millions of years of evolution. We urgently suggest that, internationally, massive action be taken to preserve this gigantic pool of germ plasm by the establishment of biological gene pool reserves from the different tropical rain forest environments of the world.

[Extracted from Science, Vol. 177,
September 1, 1972, pp. 762-765. Copyright ©, the American Association for
the Advancement of Science, Washingt
D. C.]

Editorial Comment

The above argument for preserving the gene pool of tree species, and especially "primary" species with desirable characteristics, does not constitute a case for not using the resources of tropical forests. Nor does it imply that the extension of agriculture to forested areas should be halted, for it is clear that the feeding of the fast-growing population of the world will require major increases in areas of cultivation on suitable soils in the years ahead. But it does point to the special value of planning small tree sanctuaries in carefully selected tropical areas having representative ecosystems, and beyond that to the urgent need for acceleration of research into all aspects of tropical botany, and for the development and use of appropriate methods of tropical silviculture. Up to now both the basic and applied research in this field have been focused in the temperate zones and on a very limited number of tropical species.

Aside from the establishment of plantations for a few high-valued tropical species like rubber trees or teak, silviculture in the tropics is rarely practiced. Prevalent practices include, on the one hand, the selective cutting of widely dispersed specimens of trees whose high market value justifies the costly method; and on the other, a highly wasteful ignoring of most other species, which are burned or left as slash when land is cleared. A recently inaugurated project in the U. S. Forest Products Laboratory in Madison, Wisconsin has begun to develop methods whereby the extremely heterogenous mixtures of woods found in tropical forests can be utilized together by reducing them to mixed fibers and reconstituting them into useful products at economic cost: such products include chiefly pulp and paper, but also fiberboard, particleboard, etc. (Up to now, pulp and paper have been produced with processes adapted to particular species.) While research results cannot be described before the work is done, the considerations which caused this project to be supported by the U.S. Agency for International Development indicate good possibilities for a favorable outcome.

To the extent that this use of heterogeneous tropical woods can be accomplished cheaply with widely usable technology, it would have important consequences for tropical countries. It could vastly increase the resource base of a number of countries in Southeast Asia, mid-Africa, Central and northern South America, and add to the supply of paper, housing materials, etc. at reasonable cost — products which are increasingly in demand around the world. At the same time it might accelerate the kind of destructive cutting of forested areas that would have environmental impact, and might also result in greater danger of the loss of tree species noted in the preceding article. Once the commercial exploitation of miscellaneous woods becomes feasible, it will be all the more necessary to proceed with planned efforts to replant trees, to learn more about characteristics of tropical species and how best to manage such forests, and to establish selected forest reserves. However, the existence of these commercial opportunities should also provide greater financial incentives to invest in research and tropical forest management, incentives which have been relatively weak in the past. As in the American South (see Smyth's article above), the economics of large pulp mills needing a long term assurance of supply are a powerful inducement to the replanting of forests with desirable species.

[Composed by the editor with the advice of Edward Cliff, Forestry Consultant, Washington, D. C., 1975.]

Workers at the government nursery at Thaukot, Nepal, put ash tree seedlings in boxes to transplant in reforestation program

(Photo: United Nations)

Floating logs and poles on balsa-log rafts down river to Guayaquil, Ecuador

(Photo: FAO)

The Other Energy Crisis: Firewood

Erik P. Eckholm

[Firewood is the main source of energy for fuel used by the majority of people today, but in many parts of the world it is becoming harder to find or disappearing with use. Programs for conservation and replanting are urgently needed.]

The dwindling reserves of petroleum are making headlines; yet for more than a third of the world's people the real energy crisis is a daily scramble to find the wood they need to cook dinner. Their search for wood, once a simple chore, is now a day's labor in some places as forests recede. While chemists devise ever more sophisticated uses for wood, including cellophane and rayon, at least half of all the timber cut in the world still fulfills its original role as fuel for cooking and, in colder regions, a source of warmth. Nine-tenths of the people in most poor countries today depend on firewood as their chief source of fuel. And all too often, the growth in human population is outpacing the growth of new trees — not surprising when the average user burns as much as a ton of firewood a year. The results are soaring wood prices, a growing drain on incomes and physical energies in order to satisfy basic fuel needs, a costly diversion of animal manures to cooking food rather than producing it, and an ecologically disastrous spread of treeless landscapes.

The firewood crisis is probably most acute today in the densely populated Indian subcontinent, and in the semi-arid stretches of central Africa fringing the Sahara Desert. In Latin America, too, scarcity of wood and charcoal is a problem throughout most of the

Mr. Eckholm is a Senior Researcher with
Worldwatch Institute, Washington, D. C.

Andean region, Central America, and the Caribbean.

An Economic Burden

The costs of firewood and charcoal are climbing throughout most of Asia, Africa, and Latin America. In Niamey, Niger, the average manual laborer's family now spends nearly one-fourth of its income on firewood. In Ouagadougou, Upper Volta, the portion is 20-30 percent. Those who can't pay so much may send their children, or hike themselves, out into the surrounding countryside to forage — if enough trees are within a reasonable walking distance. Otherwise, they may search about the town for twigs, garbage, or anything burnable. In some Pakistani towns now, people strip bark off the trees that line the streets; thus, meeting today's undeniable needs can impoverish the future. The rural landless poor in parts of India and Pakistan are now facing a new squeeze on their meager incomes. Until now they have generally been able to gather wood for free among the trees scattered through farmlands, but as wood prices in the towns rise, landlords naturally see an advantage in carting available timber into the nearest town to sell rather than giving it to the nearby laborers. While this commercialization of firewood raises the hope that entrepreneurs will see an advantage in planting trees to develop a sustainable, labor-intensive business, so far a depletion of woodlands has been the more common result. Even the essential national forest reserves are not untouched. The gravity of the poaching problem in India has been reflected in the formation of special mobile guard-squads and mobile courts to try captured offenders, but law enforcement measures have little effect in such an untenable situation. Acute firewood scarcity has undermined administrative control even in China, where trees on commune plantations are sometimes surreptitiously uprooted for fuel almost as soon as they are planted.

Ecological Consequences

The accelerating degradation of woodlands throughout Africa, Asia, and Latin America, caused in part by fuel gathering, is undermining the productivity of the land itself through soil erosion, increasingly severe flooding, creeping deserts, and declining soil fertility. All these problems are accentuated by deforestation, which is spreading as lands are cleared for agriculture and as rising populations continue their search for firewood. Around the Rajasthan Desert in northwest India, overgrazing by cattle, goats and sheep is the chief cause of land degradation, but fuel-wood gathering is also an important contributor to the destruction of trees. Throughout the sub-Saharan fringe of Africa from Senegal to Ethiopia, the caravans that bring in firewood are contributing to the creation of desert-like conditions in a wide band below the desert's edge. Virtually all trees within 70 kilometers of Ouagadougou have been consumed as fuel by the city's inhabitants, and the circle of land "strip-mined" for firewood — without reclamation — is continually expanding. Similar pressures of overgrazing and deforestation in North Africa are having the same consequences.

In the Indian subcontinent, the most pernicious result of firewood scarcity is perhaps not the destruction of tree cover itself, but the alternative: pyramids of hand-molded dung patties drying in the sun. In many areas these dung cakes have been the only source of fuel for generations, but now, by necessity, their use is spreading further. Between 300 and 400 million tons of wet dung — 60 to 80 million tons when dried — is annually burned for fuel in India alone, robbing farmland of badly needed nutrients and organic matter. The plant nutrients wasted annually in this fasion in India equal more than a third of the country's chemical fertilizer use.

Peasants in the uplands of South Korea have found another, equally destructive way to cope with the timber shortage. A United Nations forestry team visiting the country in the late 1960s found not only live tree-branches, shrubs, seedlings, and grasses being cut for fuel; many hillsides were raked clean of all leaves, litter, and burnable materials. Raking in this fasion, to meet needs for home fuel and farm compost, robs the soil of both a protective cover and organic matter, and the practice was cited by the U. N. experts as "one of the principal causes of soil erosion in Korea." Firewood scarcity similarly impairs productivity in Eastern Nigeria, where the Tiv people have been forced to uproot crop residues after the harvest for use as fuel. Traditionally, the dead stalks and leaves had been left to enrich the soil and hold down erosion.

Rainwater falling on tree-covered land tends to soak into the ground rather than rush off; erosion and flooding are thus reduced, and more water seeps into valuable underground pools and spring sources. But with the loss of tree and plant cover, soil erosion has many adverse consequences. Around the northern and southern edges of the Sahara, the desert is advancing. When tree cover is lost on hill or mountain slopes, the soil is washed away and fertility lost. When soil washes away it must relocate somewhere, and the rising load of silt carried by Asia's rivers is choking up expensive reservoirs behind major dams, and filling irrigation canals. Most threatening of all to food production prospects on the Indian subcontinent, where nearly one in every five human beings lives, is a rise in the frequency and severity of flooding in Pakistan, India, and possibly Bangladesh, the result of denuded watersheds off which rainfall rushes quickly, and of the excessive load of sediment from upstream that builds up river beds, reducing their capacity to channel water.

A Renewable Resource

The unfortunate truth is that the amount of wood burned in a particular country is almost completely determined by the number of people who need to use it. In the absence of suitable alternative energy sources, future firewood needs in these countries will be determined largely by population growth. The simple arithmetic of exponential growth suggests the immensity of the fuel-wood challenge facing many poor countries. As Table 1 shows, for example, 99 percent of Tanzania's population burns an average of 1.8 tons of wood per person each year. Since Tanzania's population is now just over 15 million, about 27 million tons of wood will be burned for fuel in 1975. But if Tanzania's population should continue growing at the present rate of 2.7 percent annually, it will multiply 14-fold in a century. If the proportion of wood users should remain constant, the consumption of wood for fuel would then reach 370 million tons per year.

Table 1: Fuel Wood Consumption in Tazania, Gambia, and Thailand

	Fuel Wood Consumption per capita (tons/year)	Fuel Wood as Share of Total Timber Consumption (percent)	Fuel Wood Users as Share of Total Population (percent)
Tanzania	1.8	96	99
Gambia	1.2	94	99
Thailand	1.1	76	97

Source: Adapted from Keith Openshaw, "Wood Fuels the Developing World," New Scientist, Vol. 61, No. 883, January 31, 1974.

Fortunately trees, unlike oil, are a renewable resource when properly managed. People can plant more trees in plantations, on farms, along roads, in shelter belts, and on unused land throughout the rural areas of the poor countries. The concept is simple, but its implementation is not. Governments in nearly all the wood-short countries have had tree-planting programs for some time — for several decades in some cases. But several problems have plagued these programs from the beginning. One is the sheer magnitude of the need for wood, and the scale of the growth in demand. Population growth has swallowed the moderate tree-planting efforts of many countries, rendering their impact almost negligible. Wood-producing programs will have to be undertaken on a far greater scale than most governments presently conceive if a real dent is to be made in the problem. A second major obstacle to meeting this crisis is the perennial question of political priorities and decision-making time frames. It is hard for any politician to concentrate funds and attention on a problem so diffuse and seemingly long-term in nature. Some ecologists in the poor countries have been warning their governments for decades about the dangers of deforestation and fuel shortages, but tree-planting programs don't win elections.

Most of the regions with too few trees also have too many cattle, sheep, and goats. Where rangelands are badly overgrazed, the leaves of a young sapling present an appetizing temptation to a foraging animal. Even if he keeps careful control of his own livestock, a herdsman may reason that if his animals don't eat the leaves, someone else's will. Marauding livestock are prime destroyers of tree-planting projects throughout the less developed world. Even if a village is internally disciplined enough to defend new trees from its own residents, passing nomads or other wanderers may do them in. To be successful, then, reforestation efforts often require a formidable administrative effort to protect the plants for years — not to mention the monitoring of timber harvesting and replanting activities once the trees reach maturity.

In country after country, the same lesson has been learned: tree-planting programs are most successful when a majority of the local community is deeply involved in planning and implementation, and clearly perceives its self-interest in success. Central or state governments can provide stimulus, technical advice, and financial assistance, but unless community members clearly understand why lands to which they have traditionally had free access for grazing and wood-gathering are being demarcated into a plantation, they are apt to view the project with suspicion or even hostility. With wider community participation, on the other hand, the control of grazing patterns can be built into the program from the beginning, and a motivated community will protect its own project and provide labor at little or no cost. An approach like this — working through village councils, with locally-mobilized labor doing the planting and protection work — is now being tried in India. This approach too has its pitfalls and it may be somewhat utopian. But if it can get underway on a large scale, the fast-growing trees bring visible benefits quickly, and they just could catch on. The Chinese have long used the decentralized, community labor-mobilizing approach to reforestation, apparently with moderate success.

Alternative Fuels

The wider substitution of other energy sources for wood would, if feasible, contribute greatly to a solution of the firewood problem. In the poor countries the proportion of wood users is falling gradually, especially in the cities, as more residents cook their food with bottled gas or kerosene. Yet events of the last two years have abruptly altered energy-use trends and prospects everywhere. Kerosene, the most feasible substitute for firewood, has now been pulled even farther out of reach of the world's poor than it already was. The hopes of foresters and ecologists for a rapid reduction of pressures on receding woodlands through a stepped-up shift to kerosene withered overnight in December, 1973, when OPEC announced its new oil prices.

Fossil fuels are not the only alternate energy source, and over the long term many of those using firewood will have to turn in other directions. Nothing, for example, would be better than a dirt-cheap device for cooking dinner in the evening with solar energy collected earlier in the day. While some solar cookers are already available, the cost of a family unit, at about $35-$50, is prohibitive for many since, in the absence of suitable cridit arrangements, the entire price must be available at once. Furthermore, no inexpensive means of storing heat for cloudy days and for evenings has yet been devised.

Indian scientists have created a "bio-gas" plant which breaks down manures and other organic wastes into methane gas for cooking and leaves a rich compost for the farm. Over eight thousand of these plants are now being used in India. Without a substantial reduction in cost, however, they will only slowly infiltrate the thousands of rural villages where the fuel problem is growing. Still, it is scientific progress with relatively simple, small-scale devices like solar cookers and bio-gas plants that will likely provide the fuel source of the future in most poor countries.

[Extracted from The Other Energy Crisis: Firewood, Worldwatch Paper No. 1, September 1975. Copyright ©, Worldwatch Institute, Washington, D. C.

Fuel wood for market in Nepal

(Photo: FAO)

FARM MACHINERY

EXPERT DEMONSTRATES A PLOW IN
UPPER VOLTA (PHOTO: WORLD BANK)

The Economics of Farm Mechanization in Developing Countries

Gordon Gemmill and Carl Eicher

[This article supplies an introductory overview of the methods used to analyze the process of mechanization in agriculture, and indicates some of the problems technicians have faced in applying these methods. It includes examples of some of the conclusions of researchers bearing on agricultural efficency and output, employment, and income distribution.]

Many developing countries face major decisions on how rapidly they should mechanize their agriculture and on the role of the public and private sectors in this process. To ignore such decisions is to make them by default. The decisions are particularly acute since underemployment and unemployment are rising in many such countries. Mechanization involves the substitution of capital for labor, but there may also be a counterbalancing increase in the demand for labor following mechanization due to increases in cultivated acreage and crop intensity. Therefore, a careful empirical analysis is required if the outcome of each alternative policy is to be predicted.

Government has at its disposal an array of policies which affect mechanization. At the one extreme, government may simply allow mechanization to occur at the rate decided by free-market forces and accept the social consequences. At the other extreme, government may be directly involved in controlling the mechanization process. Policies which affect mechanization

Dr. Gemmill is a Lecturer in Economics at Wye College (London University) in Ashford, Kent, England, and Dr. Eicher is a Professor of Agricultural Economics, Michigan State University, East Lansing, Michigan.

may conveniently be divided into short, medium and long-term categories. We define short-term policies as those directly affecting mechanization, such as subsidized tractor-hire and the inclusion of mechanization in government agricultural projects. Medium-term policies are more indirect and less immediate in their impact: for example, the establishment of a domestic farm machinery industry. Long-term policies take effect over several decades in accordance with some vision of the type of society to be established. Very roughly, short-term policies have a horizon of 0-5 years, medium-term policies of 5-15 years and long-term policies of more than 15 years.

The economic analysis of mechanization policies may be considered at two levels of abstraction. First, there is the more technical question of the amount of change in output, employment and income which will result from each policy. Second, there is the question of who will bear the costs and who receive the benefits, i. e., what will be the result of each policy on the distribution of income, wealth and power in society?

Economists have often condemned rapid mechanization with only a rudimentary (if any) empirical analysis. They have made prescriptions which are clearly normative, such as "all factor-price distortions should be removed" or "mechanization is bad because it displaces labor." As several researchers have shown, the mechanization question is an empirical one which cannot be solved with rules of thumb or cursory analysis. Economists often condemn agricultural engineers for using such rules of thumb as "0. 2 h. p. per acre is the minimum acceptable level" or the concept of a "mechanization ladder" as guidelines for policy-making; but the economists are equally guilty of reaching conclusions in the absence of thorough empirical analysis. This ADC/RTN Seminar brought together a group of economists and one engineer, who were currently engaged in research on farm mechanization in developing countries, in order to examine alternative methods of analysis.

An Overview of the Mechanization Controversy

Let us define mechanization as any form of power used to assist or replace hand labor in agriculture. This definition therefore includes ox-power as well as tractors, along with the implements to be used with both. The proponents of mechanization have included many agricultural engineers, who have emphasized the technical efficiency of greater mechanization, and the land-owning members of society who view mechanization as a way to increase their own incomes, often via the displacement of tenants. The opponents of rapid mechanization have included most sociologists and economists, who have emphasized both the role of mechanization in creating unemployment and the unequal distribution among rural people of the benefits arising from mechanization. We consider the mechanization of agriculture to be inevitable;

the real questions are how rapidly the process of mechanization should be allowed to occur and what types of machinery are appropriate.

The heart of the controversy is the conflict between goals which occurs in any society. Let us suppose that the government has some stated goals, such as increasing GNP, increasing employment and avoiding a very unequal distribution of income. Let us further suppose that the government has two possible policies in mind: the first is to build a tractor-manufacturing plant and rapidly mechanize agriculture by providing tractors at a price less than the cost of production; the second is to impose very high import duties on tractors and fuel and to encourage the use of ox-power via an agricultural extension service and credit agencies. Assume that the first policy leads to greater output, lower food prices, higher unemployment and a less equal distribution of income than the second policy. Which policy is the "right" one? That depends on the importance of one goal relative to another. Economists and engineers often place different values on these goals, due to their disciplinary orientations, so they give conflicting policy advice.

Let us turn to the data and analyses from which prescriptions are drawn by economists. First, we must decide what sort of data are needed, i. e., what effects mechanization may have; we then need to collect representative data to examine these effects. For example, one may summarize the types of losses and gains which may occur (and therefore need to be measured) when bullock-power is replaced by tractors in a given situation. The most important economic changes concern possible increases in acreage cultivated, increased timeliness and higher yields, changes in crop mixture, costs of machinery and fuel, saving of labor, and saving of land previously used for bullock fodder. Social gains may include an increase in leisure, and social losses may include unemployment and a widening of income differences. Thus, an extremely large number of variables need to be measured in evaluating the impact of a single change in technology on-farm. But the researcher also needs to aggregate over a representative sample of farms and villages if he wishes to reach conclusions on the way in which a certain regional or national level of mechanization would affect society's goals (of GNP, employment and equitable income distribution). In this assessment the researcher also needs to look at possible backward linkages, such as employment in machinery manufacture, and forward linkages, such as lower food prices and hence higher real incomes, leading in turn to increased consumption demand. In the discussion which follows we will look at different approaches to relating the losses and gains in reaching policy prescriptions, giving examples of the kind of results often found when a particular approach is used.

Table 1. Classification of Economic Studies of Farm Mechanization in Less Developed Countries[a]

	Short-term (Static)				Medium-term (Dynamic)			Long-term (Perspective)	
	Cost-Benefit	Cross-Section	Linear Programming	General Equilibrium	Budgeting	Programming	Simulation	Historical	Instrumental
Local	Baldwin [1957] Chancellor [1969] Dalton and Enikwaw [1971] Ellis [1972] b/ Green [1971] b/ Kolawole [1972] Laurent [1968] Lidman [1968] b/ Lord [1963] Peacock [1967] Purvis [1968] Renaut [1966] Van Wersch [1968] Weil [1970] Yudelman [1971]		Ahmad [1972] Clayton [1965] Gotsch [1973-a]						
Regional	Chopra [1972] Gemmill [1971]	Donaldson and McInerney [1973] Inukai [1970] Johl [1970] Rao [1972]	Panagides and Ferreira [1970] Vaurs [1971]		Singh and Billings [1971]	Singh and Day [1972] Singh and Ahn [1972]		Day [1967]	
Countrywide	Bose and Clark [1969] b/ Kaneda [1969] b/ Timmer [1972-a] b/ Weitz-Hettelsater Engineers [1971]			Thirsk [1972] Sanders [1973]	Johnston, Cownie and Duff [1970] Johnston and Kilby [1972]		Johnson, et. al. [1971] Rossmiller, et. al. [1972]	Jasny [1936] Kautsky [1900] Marx [1966] Miller [1970] Mesa-Lago [1971] Roberts [1972] Wheelright and McFarlane [1970] Whetham [1970] White [1964]	Gotsch [1972] Schmitz and Seckl [1970]

a/ Readers wishing to fully identify these studies may consult the original of this article.

b/ These cost-benefit studies were economic rather than just financial in nature (see text for explanation).

Methods of Analysis of Mechanization

A review of the literature reveals that most economic studies of mechanization, while using sophisticated methods of analysis, have relied on very dubious assumptions to compensate for their lack of representative data. Unjustifiably generalized conclusions have been drawn from studies of single mechanization schemes or limited geographical areas. Economic studies of mechanization have usually been the products of lone economists who have not had the resources to analyse a number of alternative technologies and the labor, input (capital) and product markets. Few studies have looked at the effect of population growth on labor supply or have examined the sensitivity of their results to changes in some key parameters. Table 1 classified some of the most important studies of mechanization according to the type of policy decision (short, medium or long-term) to which the research was, either implicitly or explicitly directed along with the methodologies used.

Cost-benefit analysis. Our chosen study is that of Timmer in 1972 on the choice of milling facilities for rice in Indonesia. An engineering firm completed an appraisal in 1971 and recommended that a small number of large, capital-intensive facilities be established throughout the country. The engineers conducted a financial cost-benefit analysis in which the costs and benefits were valued at current market prices. Timmer completed an economic or social cost-benefit analysis in which he corrected for certain distortions of the market price such as overvalued currency exchange rate. More importantly, Timmer assumed that the real cost of labor was lower than the market-hiring price. His conclusions were in direct contradiction with those of the engineers. The latter recommended equipment costing $63.2 million and employing 7,300 people while Timmer recommended small power-mills at a cost of $12.5 million and employing 14,700 people. Timmer's study ably demonstrates the importance of economic rather than merely financial analysis for decision-making.

Cost-benefit analysis is the simplest approach to the appraisal of mechanization. It is very useful, but has generally been confined to a single alternative to the present system, when many alternatives may in fact exist. However, the method can handle multiple alternatives. Timmer was provided by the engineers with a very full report on technical input-output relationships for the five types of rice mill under consideration. Obtaining such data on alternative mechanization options for an entire country can be very expensive. A second shortcoming of many studies has been their concentration on financial rather than economic analysis for policy-making.

Cross section and time series. A second approach to short-term policy research is to conduct a cross-section survey of farmers in an area where several levels of mechanization are in coexistence. Alternatively the researcher may do a "before" and "after" analysis of selected farmers thus constructing a time-series. Donaldson and McInerney (1973) attempted to combine both approaches — cross-section and time-series — in a study of the impact of tractors in Pakistan. They interviewed 208 farmers, located mainly in the Pakistan Punjab, who represented a 3.5 percent random sample of the farmers accepted for World Bank tractor loans. The farmers were questioned about the 1966/67 (before loan) and 1969/70 (after loan) seasons. Only half of the farmers interviewed in 1971 had actually received loans, so the researchers believed that they would obtain a good comparison of mechanized and nonmechanized farms. Unfortunately, most of the farmers who had not received loans had also mechanized their farms in the intervening period.

The usual approaches to analyzing such surveys are to use chi-squared tests, analysis of variance, and regression analysis. Donaldson and McInerney used chi-squared tests. Their major finding was that, following mechanization, the size of farm operations by owners had grown by 240 percent. This growth was predominantly accomplished by the eviction of tenants, although some land was brought into cultivation and other land was bought or rented. This study gave a very clear indication of the level of tenant eviction which followed mechanization in this area. Several seminar participants had reservations about the sample used and the accuracy of recalled information on such parameters as cropping intensity. Nevertheless, the usual cross-section studies have used even less accurate information and, as a consequence, attributed all observed changes to mechanization.

Linear programming. This approach is best suited to analyzing the impact of mechanization on individual farms; i. e., in a linear programming study one would analyze a small number of farms intensively rather than obtaining a broad overview such as comes from a cross-section survey. Bashir Ahmad conducted a small cross-section survey in Pakistan and then programmed a representative farm which had been extracted from the survey. Running the program with different levels of mechanization gives an indication of changes in output, income and employment following mechanization under various clearly specified conditions. Ahmad's chief finding was that the financial incentive to mechanize with tractors was very great if the farmer had a supplementary supply of water available.

A frequent problem in application of the linear programming approach is its conventional assumption that the farmer maximizes profit, subject to certain defined constraints. Alternative objectives, and especially that of risk-aversion, are not easily incorporated into this method, although it can be done. Nevertheless, it is probably the best tool available for short-term analysis on individual farms, and this accounts for its widespread use in America and Western Europe.

General equilibrium models. Thirsk in Colombia, and Sanders in Brazil, have examined the factors influencing the rate of mechanization for a whole country, using aggregate data. These are "general equilibrium" studies because they begin by assuming that a country's factor and product markets are at a static equilibrium. They then attempt to show what equilibrium would exist under alternative factor and product prices.

Thirsk was interested in discovering whether the Colombian Government's policy of providing credit for mechanization at half the market rate of interest had increased or decreased GNP and employment, and whether the benefits of mechanization had accrued to (the owners of) land, labor or capital. Using data from a variety of sources, including a national farm management survey and the National Accounts, he estimated the elasticity of substitution between labor and capital in agriculture as approximately 1.4, a figure similar to that in other countries (Sanders found a similar figure in Brazil). He then built a small simultaneous equations model of Colombian agriculture, concluding that the subsidization of mechanization had lowered GNP, favored the capital-owning segment of society, and resulted in lower agricultural employment.

Thirsk's work was analytically very elegant and did show the effect of one government policy. Such aggregate analysis would be a useful complement to micro-studies in moving from short-term into medium-term analysis. However, as Thirsk suggested, institutional questions such as land reform may be of much greater importance in Colombia's development than the question of whether to subsidize mechanization. The analysis did not indicate what should be done next with respect to policies for mechanizing agriculture.

Recursive programming of representative farms. This approach is in the medium-term category, since it is an attempt to simultaneously examine production and investment through time on representative farms. Other possible medium-term approaches listed in Table 1 include simple budgeting through time, such as the work of Johnston, Cownie and Duff (1970), and the simulation approach to agricultural policy evaluation of Rossmiller et. al. (1972).

At the seminar I. J. Singh discussed his work with recursive linear programming in the study of agricultural development in the Indian Punjab (Singh and Day, 1972). This work was initially intended as a study of the underlying factors in operation as agricultural development occurs. The study treated mechanization as one factor influencing the process of development. The method consists essentially of a series of annual linear programs, the constraints on one year's program being dependent on the results of the previous year's program. Using their model Singh and Day simulated the impact of new technology (including mechanization) in the Punjab for 1952-65 and also made projections to 1980. They predicted that the absolute demand for labor would decline 10 percent between 1970 and 1980 because of mechanization, and this would result in a surplus of labor. The rate of mechanization was shown to be insensitive to small changes in wage and interest rates, hence the potential influence of government policy affecting these factors was severly limited.

Recursive linear programming is undoubtedly a useful approach to analyzing firm growth over time, but its capacity to make regional projections is questionable: it treats a region as an aggregate having one or a small number of farm types. Changes in the pattern of land ownership, input industries, and the labor market could be incorporated, but the resulting model would be a "monster." Perhaps recursive linear programming could be used for a micro analysis of representative farms in conjunction with a more conventional budgeting approach to macro appraisal.

Long-term instrumental research. These studies are concerned with showing the effects of different institutions on long-term development. An example is the work of Carl Gotsch (1972), who compared the impact of mechanization in Pakistan with that in Bangladesh, concluding that the impact in Pakistan had been less equitable due to the different institutions there. Notably, the distribution of land, capital and power in the two societies was different. In Bangladesh (divisible) tractor-hire had spread the benefits of mechanization, whereas (indivisible) private ownership in Pakistan had led to eviction of tenants. Gotsch believed that economic studies needed to be integrated into a political and social framework if they were to be relevant for decision-making.

In the seminar, Gotsch contended that it was not sufficient to present a decision-maker with some alternative policies. He urged researchers to find ways to actively implement their policy recommendations. The activist should be subtle, however. For example, it would be useless to condemn tractor mechanization when discussing the matter with a Minister if the latter's brother-in-law had a large farm benefiting from rapid mechanization. Gotsch felt that in such a situation the researcher would be wiser to demonstrate to the decision maker the trade-off between personal financial gain and potential social unrest following rapid mechanization and tenant displacement. He suggested that institutional questions had received too little attention. For example, tractor subsidization as a factor-price distortion is approximately equivalent in importance in most countries to agricultural taxation. But land reform is often of far greater importance in combating the spread of socially undesirable mechanization than the removal of either subsidies or taxes.

Gotsch sketched out a block diagram of the general decision-making environment to show how the national regime, government bureaucracy and local power structure each influenced the choice of technology and interacted with each other. He believed that the seminar had concentrated too narrowly on the simple economics of technological choice without concern for the political environment. In some countries, students, the military, and the urban populace might be more important in determining policy than anyone in the agricultural sector. There was disagreement by some participants on Gotsch's definition of the role of the economist. Some argued that the greatest need at present was for an improvement of farm and regional-level analysis of income, employment and equity following mechanization, feeling that one could not approach the decision-maker until a thorough, basic analysis had been completed. Other participants believed that the economist could make allowance for the political environment by proposing an extreme policy, while really hoping to find acceptance for a more "palatable" second-best policy. To summarize this difference of viewpoint, Gotsch argued for an analysis of the effects of redistribution of property-rights (e. g., land reform) whereas traditional economic analysis takes the distribution of property-rights as given.

Selective mechanization. Mechanization is so country- and commodity-specific that it is impossible to give general policy recommendations. It is also fruitless to discuss "a national mechanization strategy to minimize labor displacement" or "policies to maximize agricultural development while minimizing social conflict." Researchers should recognize that there are trade-offs between goals, and that the most acceptable policy on mechanization will necessarily be a compromise between alternative goals. One type of policy which embodies such a compromise would be selective mechanization to overcome specified seasonal labor bottlenecks without leading to the mechanization of all farm operations.

[Extracted from Report No. 4 of
the Research and Training Network
Agricultural Development Council
New York, 1973. The seminar
described was held at Michigan State
University, March 1973.]

Note: This article is intended as an introduction to the kinds of analytical methods used for the subject and some of the problems they often present to policy makers, rather than a discussion of the relative virtues and potentialities of each method *per se*. Readers may wish to explore the literature cited in the references found in the original of this article, or they may obtain a fuller discussion of the mechanization question by the same authors, free on request, as African Rural Employment Paper No. 4, Department of Agricultural Economics, Michigan State University, East Lansing, Michigan, 48824, U. S. A.

Village Technology in Tanzania

George MacPherson and Dudley Jackson

[The kinds of technology most useful for agricultural development in Tanzania were explored in a project which examined alternative possibilities ranging from full mechanization to very simple indigenous tools. Reasons for choosing particular implements at different technological levels are anlyzed.]

The villages of Tanzania are very poor. The country had a per capita income — including subsistence output — in 1971 of 657 Tanzanian shillings (about US$92 or £36). In this context, the importance of differences in cost between technologies can hardly be exaggerated. Table 1 provides some illustrative data on the cost of basic farm equipment, comparing the prices of imported tractor-powered equipment with those of ox-powered implements produced in Tanzania. For the items listed, the latter cost only 5.6 percent of the tractor-powered equipment. This differential concerns only the initial capital outlay, and does not take into account the further difference in running costs. Even though the tractorized equipment is more efficient in handling large acreage, and may have important technical advantages, the reality of the farming situation is that such a cost differential puts the mechanized equipment out of reach of the great majority of villages. It therefore becomes important to develop a tool technology that is accessible to subsistence farmers.

Mr. MacPherson is Assistant Editor of Big Farm Management magazine, London; and Mr. Jackson is Research Officer, University of Cambridge, Department of Applied Economics, Cambridge, England. Both worked in Tanzania on the project described.

Table 1. Comparative Capital Costs of Mechanized and Intermediate Technology
(Tanzanian shillings[1])

Equipment	Mechanized technology (tractor-powered)	Intermediate technology (ox-powered)
Tractor (TMC, 47-hp)	36,800	-
Tractor trailer (UAC, 3-ton)	5,800	-
Four oxen (each sh. 500)	-	2,000
Ox-cart (TAMTU)	-	710
Plough (UAC, TAMTU)[2]	5,610	545
Cultivator (UAC, UFI)	9,000	192
Harrow (UAC, TAMTU)	7,250	175
Total	64,460	3,622

[1] In August 1973 the exchange rate was 6.9 shillings per US dollar.

[2] The UAC tractor-plough is 3-furrow; the TAMTU ox-plough is 2-furrow.

Source: TMC — Tanzania Motor Corporation, price quoted for named model, August 1973; UAC — United Africa Company, quoted prices, August 1973; TAMTU — Tanzania Agricultural Machinery Testing Unit, price list, August 1973; UFI — Ubungo Farm Implements, price list, May 1973.

Village Technology Project

With the help of the United Nations Development Programme and two International Labour Office experts and their Tanzanian counterparts, a project was undertaken to study and introduce a program of "intermediate technology" (hereafter referred to as "the Project"). The task of one expert was to assist in the co-ordination of work among various ministries and other organizations concerned with rural areas, while the other was to work with TAMTU (Tanzania Agricultural Machinery Testing Unit) on the design and construction of equipment prototypes suitable for village use. For this latter part of the Project it was decided that the work undertaken should conform to the needs the villagers themselves regarded as important. This was largely because previous attempts at introducing "mechanization" had required the constant attendance of government workers such as agricultural engineers, with their relatively sophisticated management of, and accounting for, supplies of fuel and spare parts, regular maintenance, and the proper use of machinery. When the government workers were withdrawn, the machinery tended to fall into disuse for lack of one or a combination of these.

To avoid such failures, innovation should start at the current level of technical competence of the village people. In most villages there are men skilled in the use of the axe, the adze, the panga and the hoe. In many villages there are carpenters who make chairs, tables, beds, doors and houses using these implements, while in some there are smiths who forge adzes, hoes, knives, and other small tools. This provides a reservoir of basic (mostly woodworking) skills which could usefully be tapped by the Project. The use of such village skills enabled the Project to go beyond the stage of intermediate technology implements, as listed in Table 1, to implements of even lower cash cost. Although the capital costs for intermediate technology represent a very considerable saving on those for mechanized technology, the initial cash outlays may still be beyond the reach of a village operating at or near subsistence level. Furthermore, and worse, the implements of intermediate technology are mostly of metal; for construction and repair, they require labor skilled in metalworking and appropriate tools and techniques (e. g. welding). This is beyond the technical capacity of most villages, while the cash to pay for repairs may not be readily available.

It therefore becomes necessary to develop a "village technology" whereby both construction and repair can be undertaken by the villagers. This can be done by substituting wood for metal as far as possible, using materials known to and used by villagers. These include bush poles, tree trunks, planks, nails, bolts and nuts, sheets of corrugated iron, scrap iron from old vehicles, scrap rubber tires and tubes, leather and rope. Many such materials can be obtained, often for only a non-cash labor "cost," and can thus provide a feasible basis for village technology production. For instance, it is not necessary to construct an iron-spoked iron-rimmed wheel, because adequate wheels can be made by cutting two layers of planks (laid at right angles to each other) into a flat circular disc, fitting the disc into an old rubber tire, and then nailing the planks to each other and the tire to the planks. A wooden axle can then be made and fixed rigidly to the wheel. Inserted into wooden bearings containing plenty of grease, and with reasonable maintenance and the periodic application of more grease, such a wheel and axle function efficiently. In the case of a breakdown, repairs can be made on the spot by the villagers, unlike a metal wheel which may require welding. This type of technology enables the villagers, with the help of a simple and inexpensive tool-kit and their everyday skills, to construct and keep in working order a whole variety of agricultural equipment. Some examples are shown in Table 2.

Material costs are the largest itme. Poles are available from various government forestry departments at a charge per foot varying according to thickness and quality; planks can be obtained from timber merchants; bolts, nails, creosote and grease from various shops; while scrap rubber tires can be obtained from garages (a torn tire is a common occurrence on African roads, and is well suited for use in village technology).

Table 2. Village Technology Equipment and Costs
(in Tanzanian shillings)

Ox-cart	
Materials:	
Poles (whole and split)	26.25
Planks (bodywork)	67.50
Planks (wheels)	36.00
Tyres	25.00
Bolts	19.80
Nails	12.00
Creosote	12.00
Grease	3.00
Total	201.55
Labour cost (ten man-days)	52.50
Total direct costs	254.05
Tool depreciation and amortisation	50.81
Total direct and indirect costs	304.86
Interest charges	30.49
Minimum selling price or " unit cost "	335.35

Wheelbarrow	
Materials:	
Planks (body and wheel)	22.50
Poles	1.50
Tyre	2.00
Nails	3.00
Creosote	3.00
Grease	1.00
Total	33.00
Labour costs (two man-days)	10.50
Total direct costs	43.50
Tool depreciation and amortisation	8.70
Total direct and indirect costs	52.20
Interest charges	5.22
Minimum selling price or " unit cost "	57.42

Cultivator	
Materials:	
Poles	3.51
Bolts	21.60
Wire	0.50
Car springs (tines)	3.00
Total	28.61
Labour costs (two man-days)	10.50
Total direct costs	39.11
Tool depreciation and amortisation	7.82
Total direct and indirect costs	46.93
Interest charges	4.69
Minimum selling price or " unit cost "	51.62

Maize sheller	
Materials:	
Poles	3.90
Planks	6.00
Bolts and washers	3.60
Nails	3.00
Sack	2.00
Wire	3.85
Grease	1.15
Iron	1.00
Total	24.50
Labour costs (three man-days)	15.75
Total direct costs	40.25
Tool depreciation and amortisation	8.05
Total direct and indirect costs	48.30
Interest charges	4.83
Minimum selling price or " unit cost "	53.13

Source: Authors' costing

Labor is costed at sh. 5. 25 per man-day. The long-term aim of the Project was to establish a "permanent" craftsman in the village who would build and repair equipment for surrounding villages as well as for his own. In this case his food and clothing would have to be provided or paid for by his customers (even within the non-market relations of the Ujamaa village). It therefore seemed advisable to accustom the villagers to the practice of incorporating a labor cost element into their accounting so that the work would be viable on an "economic" basis.

It is also important for the villagers to charge for tool depreciation and amortization. It is most important to accumulate a fund of ready cash for tool replacement against the common event of breakage or wearing out. The rule for such charges has to be simple, and experience showed that a charge of 20 percent on direct costs would generally provide a sufficient contingency fund to keep the tool-kit going. Learning the simple accounting and record-keeping methods to keep track of inventories and tools, and to provide viable costings, is itself a valuable lesson. It provides a basis for the more complex accounting needed for future co-operative activities. Such schemes of accounting and inventory control formed an integral part of the Project. Although it proved difficult to teach even simple accounting to the villagers, a co-operative effort between the craftsmen and the senior members of the village generally solved the problem.

It is very important to the viability of village technology that it should have a flexible cost-structure, because it is possible to substitute cheaper materials for more expensive ones. In the construction of the ox-cart, for example, it is quite easy to substitute split poles for more expensive planks. Split poles require the use of more village labor, but their use lowers the cash outlay considerably. The product resulting from such substitution looks much cruder and may require more maintenance and repairs, but the villagers are not worried by such factors. Their judgements on implements are very pragmatic, and their criteria relate to serviceability rather than to looks. The extra maintenance is also of little concern provided it does not necessitate cash outlays. As compared to the costs of the ox-cart and wheelbarrow shown in Table 2, the cheaper materials described would make it possible to reduce the materials cost for the former by two thirds, and for the latter by one half.

Choices among Types of Technology

The cultivator. Labor-time for weeding is one of the notorious bottlenecks in peasant agriculture, and lack of adequate weeding can account for heavy losses in yields. Weeding between rows is traditionally carried out by hoe and requires much arduous labor. But it is technically quite feasible to do the weeding by an animal-powered

Table 3. Comparison of Weeding Costs

	Initial capital outlay	Annual amortisation	Annual repairs	Annual cost of man-days per acre	Total annual cost per acre
	Tanzanian shillings (round figures)				
Hand hoe	14	3	3	80	86
Village technology cultivator	52	10	26	40	76
Intermediate technology cultivator	192	20	10	40	70

Source: Authors' estimates.

implement called a cultivator. This machine is pulled along between rows of plants with its adjustable blades cutting the weed roots. Hand-weeding can then cope with the few remaining weeds between plants. At a cost of sh. 192, however, the metal cultivator of Ubungo Farm Implements, although an admirable device, is costly for the subsistance farmer. Breakdowns occur occasionally, and repairs or spare parts require a cash outlay at weeding time which is several months before the harvest and therefore a time of cash shortage. The Project therefore designed a cultivator which could be made and repaired in the village. The frame was made of trimmed poles or branches bolted together with simple depth and width controls. The tines, or blades, were made from old car springs, and could be shaped in the village using simple metal working techniques of heating, hammering and cutting. The cultivator was designed to have a low resistance so that one donkey or ox could pull it. The implement was well received by the farmers who were soon able to make their own versions for special needs. At a unit cost of just over sh. 50, with a cash outlay of just under sh. 29 (see Table 3), it represents an appreciable saving on the cash outlay of sh. 192 for the intermediate technology implement.

It is difficult to assess quantitatively the difference in hand-weeding costs and cultivation by either a village technology or an intermediate technology implement, but Table 3 shows the field-worker's best "guestimate." Capital outlay and annual depreciation for the hoe are small but more man-days are needed; about 15 man-days (priced at sh. 5. 25 each) would be necessary per acre per annum. With the cultivator the required number of man-days per acre falls to seven per annum, so labor "costs" are about halved, but the capital outlay rises substantially, especially for the intermediate technology metal implement. The village technology cultivator requires more maintenance, and we have estimated that five man-days per annum would be required for this purpose. However, what matters to the farmer is that this work may be done during a period when the opportunity cost of labor-time is lower. This means that although overall savings are not great, the village technology cultivator breaks a labor bottleneck by permitting more flexible use of labor-time. The metal cultivator might need repair (on average) once every two years, but this would necessitate a trip to town, possibly transporting the cultivator, and cash expenditure for transport, spare parts, and/or repairs. While the village technology cultivator costs notionally more in amortization and repair, it is important to the subsistence farmer that this cost is incurred not in cash but in his own labor-time. The difference in total costs between hand-weeding and the other techniques is not great, but the substitution of "capital" for labor does involve a considerable reduction in labor input and, given the labor bottleneck on weeding, this is a gain of great significance to the farmer. Comparing the two technologies, the difference in the initial outlays is a matter of importance: since both enable the farmer to effect the same saving in man-days required for weeding, the fact that village technology does so for a much lower initial (and cash) outlay makes his preference for it easy to understand.

Ploughing. It is possible to make a village technology plough, but it does not do as good a job as the intermediate technology iron plough, which is well tested and widely marketed in Tanzania, while the unit cost of the two is about the same. Farmers are quick to appreciate all this, and it was therefore explained to them that they should spend what cash they had on a good plough rather than on other implements which could be made more cheaply by village technology. One benefit of village technology is thus to release resources for intermediate technology in cases where the latter is technically superior and the cost difference is slight.

Much the same can be said for maize shelling and grinding. Both these operations can be done by hand or by village, intermediate, or mechanized technology equipment. Intermediate technology shellers save a substantial amount of labor-time as compared with village technology ones; moreover the work for a whole area can be done on a contract basis by one sheller which is thus worked to full capacity and so covers its costs, while the farmer's needs can be suited by paying either in cash or in kind. This costs less than the maize consumed by domestic labor shelling by hand or village technology.

For grinding, the machine hammer-mill of mechanized technology produces a white flour far superior to that ground by hand or the intermediate technology hand-operated plate-mill. The machine mill costs about 22 times more than the hand-operated mill, but its hourly throughput is 23 time greater; and while its current running costs are higher they are more than compensated by the difference in the quality of the flour and the speed with which it can be milled. This is shown by the spread of contract milling, farmers bringing their grain to the machine mill and paying either in cash or in kind. Contract milling also enables the mechanized technology equipment to be fully utilized and so cover its costs. Thus, there are cases where village or intermediate technology implements cannot compete with those of mechanized technology, just as the village technology plough cannot compete with the intermediate technology one.

[Extracted from "Village Technology For Rural Development: Agricultural Innovation in Tanzania." International Labour Review, Vol. III, No. 2, February 1975, pp. 102-112. Copyright ©, International Labour Office, Geneva, Switzerland.]

Tractors and Ox Plows in Africa

Uma Lele

[The pros and cons of introducing tractors and associated equipment, as against equipment powered by oxen, are examined in the light of African experiences in rural development projects.]

One of the frequent solutions to the joint food-labor constraint has been the introduction of mechanical implements to increase the output per unit of labor. These implements vary from simple hand-powered devices to sophisticated engine machinery. The discussion below is focused on the effectiveness of two important mechanized innovations, tractors and ox plows; both are linked to modern multicultivators and weeders, and are frequently introduced through government programs. It illustrates the nature of interactions between mechanization and labor bottlenecks on the one hand, and between mechanization and complementary innovations on the other. It is the inadequate understanding of these interactions which frequently explains the failure of the attempts to mechanize traditional agriculture.

Tractors

Tractors have often been viewed as a symbol of modern agriculture in Africa and, consequently, have been promoted through many rural development programs. Though tractors have generally proven well adapted to large-scale Western-style commercial farming, their role in development of smallholder agriculture has been less clear for a variety of reasons. First, since the labor bottleneck in peasant farming is largely seasonal, tractor services are needed at only

Dr. Lele is an economist with the
World Bank, Washington, D. C.

the few critical periods of peak labor demand. Second, tractors are most useful in field preparation but often are of little utility in weeding or harvesting. Tractors may, therefore, only postpone rather than break the labor bottleneck while doing little to alleviate the problem of under-utilization of farm labor at periods of slack agricultural activity.

Under some circumstances tractorization has aggravated labor bottlenecks rather than relieving them. For example, mid-season weeding tends to be a highly labor-demanding activity in much of peasant agriculture. When tractors are used for land preparation but not for weeding, as frequently tends to be the case, tractorization increases weeding requirements. This is because tractorization allows expansion of cultivated hectarage and, hence, of the area to be weeded. Since the mid-season weeding period is already a time of peak labor demand, an even tighter labor bottleneck may be created. Similarly, if land is prepared in advance of standard planting dates to make greater use of available tractor time, frequently weed growth becomes well established by the time crops are sown. This, too, creates additional weeding requirements.

Tractorization can, therefore, be successful only if the necessary complementary innovations are introduced to alleviate the labor constraint, especially for weeding. These may take the form of additional capital input — e. g., herbicides or mechanical weeders. Or they may be new planting techniques which reduce weed growth or facilitate weed removal as, for example, the close planting of groundnuts in Operation Arachide or the ridging of cotton in Sukumaland. However, perhaps the most useful step in this regard is to alter cropping patterns to spread the need for labor more evenly through the season. As pointed out earlier, the shortage of labor available to farming activities is largely allocative in nature. New crop mixes and restructured labor patterns can, therefore, provide farmers with the necessary extra labor availability to cope with the possible labor bottlenecks created by tractor use.

Several other problems are frequently encountered in the use of tractors in smallholder farming, including (a) the high capital costs of the equipment and herbicides, (b) the high overhead involved in maintaining and servicing the underutilized machinery, (c) the administrative problems in sharing a limited number of machines among a large number of diverse users, and (d) the technical difficulties of employing tractors under certain topographical and soil conditions.

Of course, none of the above problems is insurmountable. If tractorization is accompanied by substantial increases in productivity, the high capital and recurrent costs of mechanized farming can be justified. Maintenance problems can be partly alleviated by training local people in proper machine use and repair. Administrative problems as well as the need for scale may be corrected by the introduction of effective group or cooperative farming, or through the use of cooperative or commercial tractor-hire services. And lastly, research can single out the areas most amenable to tractor usages, in addition to providing insights into new ways of adapting mechanization to divergent physical conditions.

Much of the past evidence, however, suggests that successful introduction of tractors is difficult in smallholder agriculture. The experience with mechanized farming in Sukumaland illustrates the problems. In 1964 the Tanzanian government introduced a cotton block scheme which was hinged on the use of centralized tractor facilities. The Sukumaland region seemed suitable for mechanization since much of the land is flat, the growing season is short, and the peak labor requirements are high. Many farmers in the early 1960s were already hiring tractor services. Under the scheme, blocks of between 121.5 and 202.4 hectares were to be cultivated by tractors. Individual plots of 1.62 hectares would then be allocated to farmers for cotton production. The farmers were to raise the crop under close supervision but would retain ultimate responsibility for field maintenance and harvest activities.

The scheme never achieved the scale envisaged. Rather than the proposed ratio of 121.5 hectares per tractor, in the 1964/65 period each tractor worked an average of only 27.1 hectares. The success of the cotton blocks was linked to the assumption that intensive farming on the blocks would lead to an increase in yield per hectare more than sufficient to cover the high cost of the program. Yet, rather than the expected 540 kilograms of cotton per hectare in the 1964/65 period, yields averaged only 180 kilograms per hectare during that period. These yield levels were similar to those achieved by farmers not participating in the program. However, the cost per hectare was approximately six times as high as the cost of production of nonparticipants. By the end of the cotton block scheme's first season, costs of mechanical cultivation, fertilizer, and spraying (mostly aerial) amounted to TSh. 1.13 million. Only about one-fifth of these expenses were recovered.

The Sukuma experience indicates that careful attention has to be paid to ensure that in practice the increases in production resulting from the introduction of tractors will justify their high cost. Where labor is inexpensive, tractorization may only mean substituting high-cost capital for low-cost labor. Though there often is scope for mechanized input to farming, the introduction of manual or animal-powered equipment may be a more feasible alternative than tractors. The recognition of this fact is reflected in Tanzania's ujamaa policy, which emphasizes self-reliance among small holders and "less spectacular forms of mechanization" that are consistent with local resources [see preceding article].

Despite such a recognition in principle, David J. Vail's study ("Technology for Socialist Development in Tanzania," mimeograph, 1974) notes that in practice the promise of tractor services is frequently used as an inducement for people to form ujàmaa villages (a cooperative type of organization promoted by the Tanzanian government). Vail attributes this partly to the identification of tractor use with modernity, by both administrators and policy makers in Tanzania, and partly to the government's desire to promote its ujàmaa program rapidly among a sometimes-reluctant rural population. The alternative of fostering intermediate technology of the kind discussed below also seems to be creating a new rural elite of artisans and craftsmen, many of whom seem to use their spare time and the government-provided equpiment to produce and service farm implements for private profit. Such a development conflicts with the egalitarian principles underlying ujàmaa. Thus, though there may often be strong economic arguments for limiting the introduction of advanced technology such as tractors, compelling political considerations may constrain the use of alternate strategies. Particularly given that several difficulties are encountered in getting production under way in newly formed ujàmaa villages, there is a real danger that such political considerations may lead to a repetition of past mistakes with regard to tractorization.

Ox Plows

The introduction of ox plows to increase labor productivity often seems an attractive alternative to tractorization. Since much of the necessary equipment can be produced and the oxen raised locally, this type of mechanization avoids strain on foreign exchange. The cost of investment in a pair of oxen and a plow is, of course, much lower than that of a tractor. This lessens the need for scale and alleviates the administrative difficulties frequently associated with tractorization. There are also significantly fewer maintenance problems in the case of the ox plows.

However, the use of ox plows faces several of the same difficulties encountered with tractors. The first is the fact that, as with tractor use, ox-plow cultivation may aggravate the seasonal labor bottleneck. Von Rotenhan reports that farmers in Sukumaland using the hoe cultivation devoted about 1,490 hours a year per hectare of cotton, of which 370 hours and 430 hours, respectively, were spent on land preparation and weeding. Farmers using ox-plow cultivation spent about the same amount of time per hectare (i. e., about 1,520 hours). However, among the ox-plow-using farmers, land preparation accounted for only 120 hours, while labor input for weeding increased to 700 hours. The time saved in the early part of the season as a result of ox plowing was, thus, more than compensated by the increased labor required for weeding later. Because of the heightened weeding bottleneck that may result from using draft animals for field preparation, yields per hectare are sometimes no higher for ox-plow cultivation than for hoe cultivation. The major gain arises from expanded area under cultivation.

Thus, there may be a need, as in the case of tractors, to introduce new crops or crop mixtures that can increase productivity through inserting flexibility in the timing of farm operations. The replacement of broadcast sowing with row planting can also reduce labor bottlenecks. And, of course, there is a wide scope for the employment of low-cost implements that complement ox plows. For example, in the BDPA groundnut scheme in Mali, farmers using traditional methods devote 194 man-days per crop of groundnuts and millet. The introduction of ox-drawn multicultivators and seeders can result in a reduction of fifty man days in the labor time per crop. The additional use of a 100-kilogram ox-drawn cart can result in a further saving of twelve man days. Such an ox cart increases costs of mechanization by only 19 percent. Ox-drawn seeders are another potentially effective complement to ox plows. The Tanzania Agricultural Machinery Testing Unit in Arusha has developed an effective inter-row weeder that can be produced at a cost of $7 to $15. This instrument can result in a two-thirds to three-quarters reduction in weeding time for cotton.

Demand for such relatively simple farm implements is frequently substantial in rural areas, particularly when the introduction of such implements is accompanied by other yield-increasing agricultural technologies. In the BDPA groundnut scheme, the number of multicultivators in service increased from 89 to 466 between the 1970/71 period and the 1971/72 period. The number of seeders and carts also increased substantially. Anderson observes that an increasing number of farmers are attempting to obtain several sets of oxen and implements with the goal of expanding their cultivated hectarage. In Tanzania also, as Vail points out, ox plows and seeders are greatly in demand among farmers exposed to the new implements.

The demand for such intermediate technology indicates a strong potential growth linkage between the agricultural sector and the small-industry and service sectors of the rural economy. Promoting use of oxen, plows, weeders, and carts can create employment for craftsmen, mechanics, and cattle producers through the multiplier effects arising from increased agricultural productivity and incomes. However, as noted above, political and other considerations may limit the promotion of intermediate technology and thereby restrict these growth linkages.

The promotion of draft equipment is, however, also limited by its cost, which, though far lower than motorized equipment on a per unit basis, still represents a considerable investment for farmers. Anderson estimates that the average cost of animal traction in the BDPA groundnut scheme is about $48 per year, including the purchase of the equipment, feed costs, and depreciation. The true costs are probably somewhat higher, since the implements are subsidized, the amortization periods are quite long, and it is assumed that farmers will use young oxen that can be sold as beef cattle for more than their purchase price. Because the maximum projected revenue per hectare of groundnuts for farmers following BDPA-sponsored techniques (early sowing, fungicides, fertilizer, and so forth) is about $70, the average farmer must grow at least an extra two-thirds of a hectare of groundnuts to cover the cost of the animal-drawn equipment. This should be possible because the equipment allows a reduction of about one-third in the man-days required to cultivate a hectare of groundnuts. However, the revenue figures assume yields of 12 quintals per hectare. In the 1971/72 period average groundnut yields in the BDPA operation were only 8.1 quintals per hectare. At lower yields the economic viability of introducing animal traction becomes progressively more questionable. This is why even an intermediate level of agricultural mechanization and the related rural industrialization frequently cannot be successful without yield-increasing agricultural technologies.

In summary, it seems that both tractorization and ox-plow cultivation have a potential to increase productivity of smallholder agriculture, provided the appropriate associated inputs and innovations are introduced simultaneously. However, in most conditions ox-plow cultivation may be preferable because of its relatively greater flexibility, lower cost, and greater growth linkages with other sectors of the rural economy.

[Extracted from The Design of Rural Development: Lessons from Africa, pp. 33-38. Baltimore, Md: The Johns Hopkins University Press, 1975, Copyright ©, International Bank for Reconstruction and Development.]

IRRI Designs of Small Scale Farm Equipment for Developing Country Production

Carol Ulinski and Ann Becker

[The International Rice Research Institute has been designing farm machinery which is adapted to the needs of small rice farmers, and which can be manufactured by small producers in developing countries. In recent years IRRI designs have been produced in increasing numbers in the Philippines, and efforts to encourage production in other countries have begun. The machines and their production problems are described.]

The Agricultural Engineering Department (hereafter referred to as AED), of the International Rice Research Institute (IRRI) in the Philippines, started a program in 1965 to adapt, test and develop more suitable rice-producing equipment for uses in which the available equipment did not perform efficiently. The project first tested the performance of different kinds of equipment currently on the market, with emphasis on the performance of wheels, rotor blades, and spade lugs under flooded soil conditions. The focus was on observing the machines at work; suggestions for modification were directed to engineers of the equipment manufacturers. The AED borrowed equipment from manufacturers and conducted many of the tests at IRRI. During the years 1966 and 1967 representatives from several Japanese, Taiwanese, and American companies, including John Deere and Case, visited the AED at IRRI to obtain some idea of how their respective companies could fill the needs of rice producers.

The authors are Researchers with the
Graduate Program of Science, Technology,
and Public Policy at George Washington
University, Washington, D. C.

In 1967, the directorship of AED was filled by Dr. Amir Khan. Dr. Khan concluded that machinery developed for temperate zones and in industrialized countries could not be adapted to tropical conditions. Khan argued that agricultural equipment must be suited to the social, economic and industrial environment. He attributed the failure of developing countries to absorb foreign technology to the incompatibility of the technology with local environmental conditions. Second, he stressed the relationship between the design and manufacture of a product. He had found a lack of designs for simple machinery which could be produced with indigenous resources. The product design largely determines the production process; the failure of the development of a labor-intensive farm equipment industry in developing countries is largely due to the absence of appropriate designs.

Under his leadership, the revised objectives of the project are two-fold: 1) to develop agricultural machines which are economically suitable to small farms, ranging from 2 to 10 hectares in size (according to Khan, the farmer with a holding smaller than 2 hectares does not have the resources for investment in agricultural machinery); and 2) to design equipment which can be produced with locally available resources of developing countries. Initial program strategy included the following: (1) a survey of small Philippine rice farms to determine their equipment/machinery needs; (2) a survey of small Philippine industrial firms to appraise their production capabilities; and (3) a survey of part shops to determine which components were readily available. With these findings in hand, IRRI engineers set out to design machinery appropriate to the needs of the farmer and also to local producer capabilities and resources.

Surveys of Farmers and Manufacturers

A sample survey of rice farmers in Central Luzon during 1966-67 indicated that the size of the average farm operation is 3 hectares. The typical farmer plants one crop per year and is dependent upon the monsoons to satisfy his requirements for water. His primary power source is a water buffalo, which he uses in conjunction with a few simple implements such as harrows and plows (only one of the 114 farmers questioned owned a tractor). In all cases the source of power — be it water buffalo or tractor — is used only during the land preparation stage of the farming cycle.

Size of Holding	Power source & equipment
less than 1.5 ha.	1 plow, 1 harrow, 1 water buffalo
1.6 - 3.5 ha.	1.4 plows, 1.5 harrows, 1.5 water buffalo
3.6 ha. and more	2 plows, 2 harrows, 2 water buffalo

Requirements for labor are greatest during the following periods: land preparation, transplanting, and harvesting/threshing. Labor is readily obtainable for transplanting and harvesting as the work can easily be done by women and children. Shortages arise during land preparation, which is much more strenuous and can only be performed by men. In 1966-67 when the survey was conducted, the task of weeding did not require much labor; but IRRI specialists predicted that, as more and more farmers began planting the new high yielding rice varieties needing more intensive care, labor shortages might become a constraint in this area as well.

The AED also compiled data in several surveys on those farmers who had chosen to invest in hand tractors. Their holdings were not substantially larger than those noted above, but almost all the hand tractors belonged to farmers whose land was irrigated and who planted more than one crop each year. This is in striking contrast to the typical farmer relying on work animals for power, whose farm is dependent on rainfall and who plants only one crop per annum. A frequently expressed reason for mechanizing was time saving: preparation of land can be accomplished more quickly with a hand tractor, leaving more time for other work or for leisure, according to the farmer's taste. Also, unlike work animals which require rest periods, tractors can work throughout the day; and tractors only consume fuel while they are being used, whereas work animals must be fed daily the year round. In a 1971/72 survey, 60% of the farmer sample cited the nuisance involved in caring for an animal and the fear of theft or poisoning as the major determining factor in the decision to mechanize. But a later survey indicated that farmers were more likely to keep their water buffalo than sell them after buying a tiller.

The major problems of mechanization, according to the farmers interviewed, were: (1) the initial difficulty in obtaining a tractor, including cost and access to credit; and (2) the high prices of spare parts. Subsequent studies identified other reasons why farmers have chosen not to mechanize. A number of farmers, for example, noted that the tractors available on the market were not efficient because they bog down in the mud. Some 70-85% of the farms are tenant-operated; and the usual arrangements for the sharing of costs and returns between tenants and landlords, particularly for land preparation where the tenant pays the entire cost, had often made ownership of the machinery available up to then an uncertain and unattractive investment.

Profile of small-scale industry. According to the definition used by the AED, a firm is small-scale if it employs 4-20 people and the value of capital per employee does not exceed P4000 (The Philippine peso value is P7 = $1). These firms are on the whole more labor intensive than larger ones. Small industry accounts for 78% of firms in the Philippines but only 6% of all industrial income. These firms employ 18.4% of the manufacturing labor force, and their employees are paid on average about half as much as their counterparts in large companies. About 80% of the companies classified as small-scale are located outside of the Greater Manila area, in contrast to the larger ones which are concentrated around the capital.

The AED also undertook to identify some of the problems faced by small firms. A study of a typical single proprietorship firm, for example, in which the owner-manager is also its only engineer and designer, indicated that when the company expanded its activities the major problem became one of management. The firm had reached a size in its development which required diversification in management beyond the capabilities of a single individual. A second major problem for small firms is the lack of adequate marketing access. Many of these companies have no direct outlets for their goods and consequently produce only on special order. A third problem stems from the paucity of commercially viable products which can be competitively manufactured by the small, labor-intensive firm. For this reason some of them showed an avid interest in the design and development activities underway at the AED.

New Equipment Designs

One of the first pieces of equipment to be developed by the AED was a thresher. In the industrial countries the advent of the combine harvester eliminated the need for a thresher, and many companies no longer manufacture them. But the combine harvester has found little acceptance in the developing countries for a number of reasons, and the thresher is very much in demand. The AED commenced work on two models: a drum-type power thresher, and a table-type power thresher. The first designs of the drum-type power thresher were released to industry in 1968, and it was not commercially profitable. The table-type thresher, despite its lower production costs and simpler design, was also unsuccessful commercially. Farmers appeared to be disinterested in the hold-on type nature of both threshers, and wanted a machine with greater capacity. Consequently, IRRI engineers developed a third model — the axial floor thresher — which is the throw-in type and has four times the capacity of its predecessors. This last model is currently being produced by local firms and has been relatively popular.

Other machines designed and developed at IRRI include a seeder which can sow pregerminated rice on puddled soil, a power grain cleaner and a mechanical weeder. The weeder is in direct response to the high yielding varieties which require intensive care. The most important design, in terms of commercial acceptability, is the 4-6 hp (horsepower) tiller which was released to manufacturers in 1972.

The tiller. A comparative cost analysis of alternative power sources for rice production indicates that the most economical method for land preparation in the Philippines varies with the size of the farm. On holdings from 4 to 50 hectares, hand tractors (i. e. tillers) are the least costly method. Work animals are most economical on holdings smaller than 4 hectares; whereas four-wheel tractors become viable on holdings larger than 50 hectares. A survey in Laguna Province revealed that hand tractors are used on farms which average 4. 5 hectares in size.

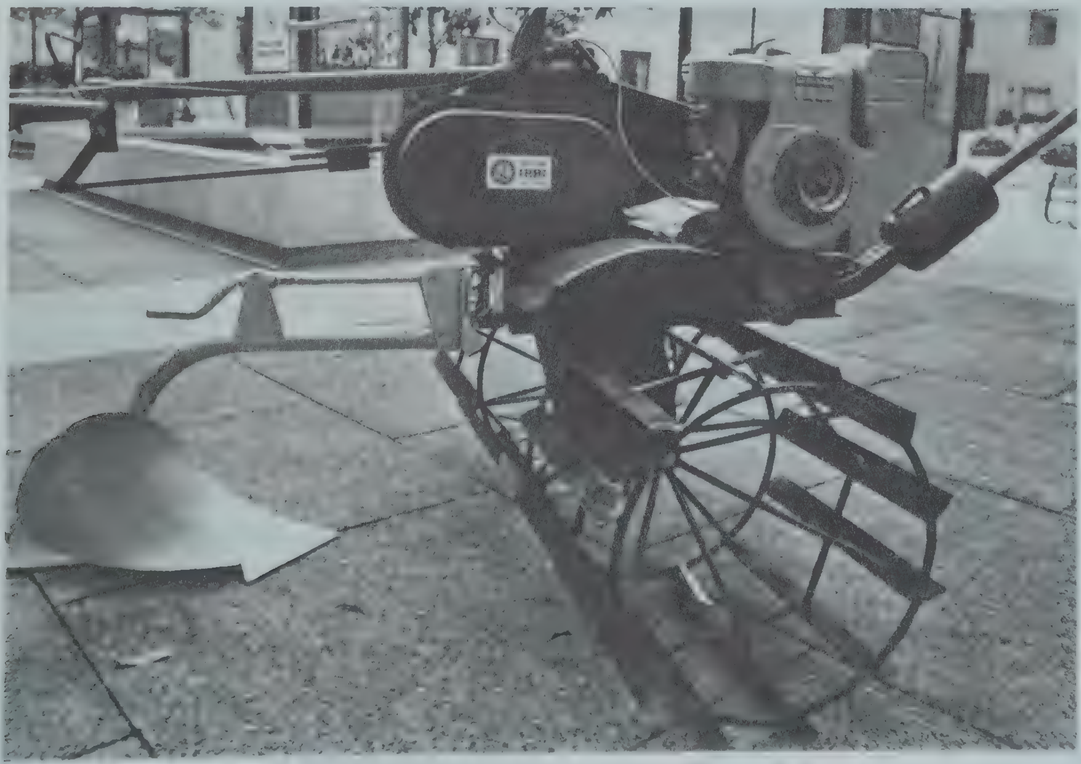
Until the AED designed a tiller for local production, the majority of hand tractors were imported. Most were imported from Japan in completely knocked down form and assembled in the Philippines. The Japanese models were expensive in the 1960s, and the devaluation of the peso in 1970 plus later revaluations of the yen substantially increased the prices of such imports. Local manufacture of the Japanese tiller within the Philippines is not practical because these machines are basically designed for capital-intensive, mass production techniques unsuited to the capabilities of the majority of Philippine companies. The AED, familiar with the success of Thai engineers in developing designs of agricultural equipment which could be produced in domestic small machine shops, set out to develop a small lightweight tiller.

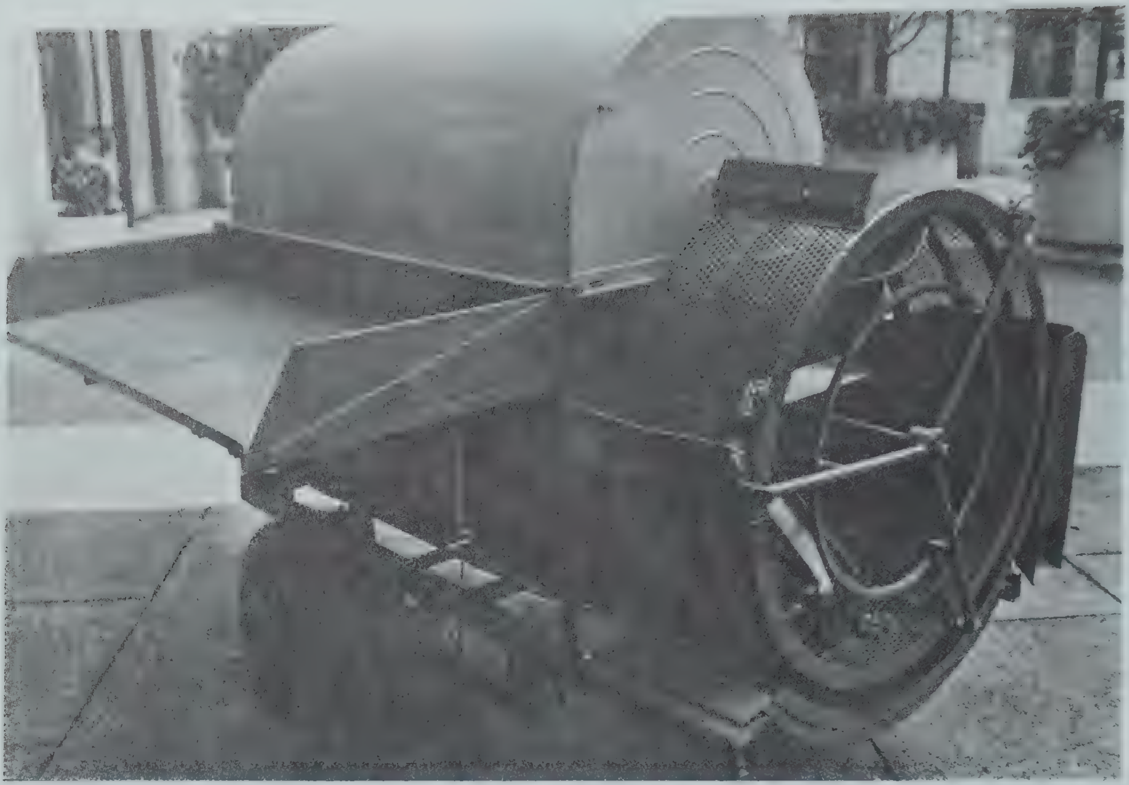
In designing the tiller, engineers had to pay particular attention to three factors. 1) The tiller must be light enough for 2 or 3 men to lift if it should bog down in mud. 2) It must be simple, so that farmers can understand how it works and local job shops can produce it with local resources. 3) An important consideration is cost: the tiller must be cheaper than imports.

The 4-6 hp tiller meets these criteria, and is without a doubt one of the most successful machines developed at IRRI. The local content of the tiller ranges from 50 to 80 percent, with the following components imported: engine, roller chains, sprockets, bearings and seals. It is relatively light (112 kg), of sturdy construction, and can perform a number of operations including plowing, puddling, cultivation and hauling. Operation and maintenance costs are low. Repairs can be done quickly and cheaply with locally available components. And it is inexpensive: the Philippine model can be purchased for P4,000 whereas the Japanese tiller, with the same performance specifications, sells for P7,000 (February 1973 prices).

A survey conducted in early 1972 indicated that somewhat larger imported tillers in the 8-14 hp range had become very popular among Philippine farmers. This demand for a more powerful product, coupled with with widespread acceptance of the 4-6 hp tiller, inspired Marsteel Co to put a larger motor into the small IRRI tiller, priced at P6200, which sells quite well. (This price compares with P28,000 for the Japanese

IRRI Power Tiller





IRRI Thresher

LEFT: Another type of thresher

BELOW: IRRI Batch Dryer.

Grain is placed on screen across middle dryer and motor pushes air underneath and up through kernals.

equivalent; foreign exchange is about one third the cost of the former, one half that of the latter.) IRRI engineers then began to develop a slightly larger 8 hp model. These designs have been released to five Philippine companies, and prototypes should be available for testing by IRRI engineers sometime in 1975.

AED has recently initiated work on the development of a small riding tractor (15-20 hp) which is tailored specifically for medium-sized farmers and small custom operators. The majority of riding tractors produced in the industrialized countries are very expensive, and their heavy weight makes them unsuitable for wetland conditions. The AED engineers are designing a tractor which is light enough for wetland conditions but which, with the addition of weights, can also be used for dryland operations. IRRI is testing this concept on an Economy tractor, which has desirable features of lightness and high clearance. This American tractor has been adapted to local conditions, and preliminary tests indicate that the new model has good mobility under wetland conditions.

Processing equipment. Increasing attention is being directed by AED to post-harvest operations such as drying and processing. The traditional system cannot adequately handle the increases in productivity resulting from the adoption of the new seed-fertilizer technology. In many of the developing countries where most of the population lives in rural areas, some 50-70% of the rice never enters an urban market. The large rural consumption of rice, and the lack of adequate transport facilities in the rural areas, indicate a need for intermediate-scale drying and processing systems for village operations.

The Japanese manufacture a batch dryer, but its cost is prohibitive for the typical Asian farmer. Another disadvantage of the Japanese dryer is that it is mass produced and therefore is not suitable to production capabilities within the Philippines. The criteria for the batch dryer are similar to those for other IRRI-designed equipment: it must be designed so that it can be manufactured with simple production methods and indigenous resources, with minimum reliance on imported components. It is hoped that the IRRI model now being developed will cost less than half that of the most sophisticated Japanese product.

The Manufacture of IRRI Designs

Contacts with industry in the industrialized countries. A Japanese company was the first to successfully produce and market an IRRI design. On a visit to the Philippines, Mr. Ohtake of Ohtake Agricultural Machinery Company Limited was exposed to and became interested in the power paddy weeder. He returned to Japan with copies of the design, which he obtained at no cost, and developed a mini-cultivator.

The machine has enjoyed a high degree of commercial success in Japan.

IRRI policy is to distribute its designs at no cost to all interested manufacturers in both industrialized and developing countries. To date, no firm has been granted exclusive rights to any IRRI-developed design. An Australian company – the National Springs Pty. Ltd. – became interested in manufacturing the IRRI thresher for export to Asian countries, and requested exclusive rights to production. The request was refused, and the company apparently found it too risky to produce an unprotected technology. Ohtake, on the other hand, has taken the risk and its mini-cultivator has proved to be extremely profitable (and it has obtained a number of patents on changes it has made in the original IRRI design – unlike any of the Philippine companies which are required to report any changes to IRRI under the standard IRRI contract, Ohtake had signed no written agreement with IRRI). The IRRI grain cleaner sparked the interest of both an American and a Japanese company, but neither has yet begun production. Two Japanese firms, however, have recently started to produce IRRI weeders.

Except for the few cases mentioned, however, such industry involvement has been minimal. The incentives to manufacture and market simple equipment for a foreign market do not appear to exist. The only justification for large companies in the industrialized countries to produce this type of equipment would be to secure a place in some market in anticipation of future market growth. To date, no firms in any Western countries are producing the IRRI designs, and there doesn't appear to be any sign of interest in catering to the small, tropical rice producer. In Japan, however, the domestic farmers' needs are closer to those in countries like the Philippines.

Production in the Philippines. Substantial efforts have been made by IRRI to introduce its designs to industry in the Philippines. In 1971 IRRI launched an extensive advertising campaign in an attempt to interest local producers. Even though the designs were being offered free of charge, few firms showed any interest in manufacturing the machines at that time. Disinterest may perhaps be attributed to a lack of risk capital and government incentives. IRRI then contracted with a number of firms to build prototypes. In 1973 the government raised its tariff from 10% to 30% on imported power tillers and tractor attachments (but not on four-wheel tractors) to encourage local industry. In the last few years production from IRRI designs has spread rapidly; by June 1975 some 20,000 IRRI machines had been produced, the most popular models being power tillers, threshers and weeders.

Procedures for releasing the IRRI designs to manufacturers follow a readily identifiable pattern. When R&D on a design has been completed, drawings and a bill of materials are released to manufacturers who have expressed an interest in the machine in question. Each submits a cost estimate for the production of a prototype, and IRRI selects a few manufacturers to perform the job, basing its choice on the cost estimates and on the firm's production facilities. More than one firm is chosen in order to encourage competition and hence "cost-consciousness" on the part of the manufacturer. Upon its completion, the prototype is shipped to IRRI where its performance is tested and evaluated. It is then returned to the manufacturer with suggestions for improvements. At this point the manufacturer must decide for himself if he wants to commercially exploit the technology. From here on in he is on his own. Although IRRI will provide engineering assistance when problems arise, IRRI cannot assist the actual marketing of the product.

After a firm makes the decision to manufacture an IRRI-developed design, a number of problems must be successfully tackled before the product reaches the ultimate consumer. These include the following: keeping a lid on production costs, pricing an unprotected technology, and marketing the finished product.

A firm in a developing country experiences great difficulty in keeping production costs low. Because the metals industry in the Philippines is relatively undeveloped, local firms must rely on expensive imports to fulfill their needs for raw materials. Purchases of materials and components are financed by short-term credit, frequently obtained at very high rates of interest. These costs are partially offset by the availability of cheap labor and by the simplicity of the IRRI design: for example, cost reductions have been made possible by reducing the number of moving parts. However, production costs remain sufficiently high to be a matter of general concern.

The firm is faced with several problems when the time comes to put a price tag on the finished product. The selling price must cover production costs and profit while remaining competitive with similar equipment manufactured by other firms who may also obtain IRRI designs at no cost. A second difficulty in pricing IRRI-designed equipment is related to the nature of the market. The machinery in question has been tailored specifically for small farmers whose resources are limited. For them, the purchase of an IRRI machine represents a major investment, and manufacturers must be sensitive to the pocketbooks of the potential consumer so as not to price him out of the market.

The existence of a reliable marketing system may be critical to the commercial sales of a new product. The larger factory's physical location may be far removed from the actual market. The distributor, either in the form of a company branch or a dealership, bridges the gap between the factory and the consumer. In this respect, the larger companies have a distinct advantage over the smaller firms and local job shops, as the latter often lack a sales organization and sell only to local farmers. In the case of the IRRI-designed equipment, experience has shown that it is desirable to introduce new machines through manufacturers who are well established and have their own sales organization. Custom fabrication shops may be effective in building made-to-order machines but generally do not have the necessary organization to effectively develop the potential for a new machine.

The importance of a marketing system is well illustrated by the case of Marsteel, the largest manufacturer of IRRI designs in the country. It has been suggested that the IRRI machines gained popularity in the Philippines only after this firm started producing the 4-6 hp tiller and marketing it through the 40 established Marsteel outlets throughout the country. A spin-off effect of this tiller's success was to generate interest in it among small firms and job shops. The Marsteel-produced power tiller has become, unintentionally, an excellent form of advertising: it has permitted small manufacturers throughout the country to become acquainted with the designs, and to discover for themselves that the technology can be produced cheaply with available capital resources. Luis Bernas, Marketing Manager of Marsteel, informed us that his company is actually encouraging small firms to enter the market. According to Bernas, proliferation of small firms manufacturing agricultural equipment is a low-cost, effective method for developing the market for said products. Once the market has been developed the battle will be to capture the largest possible share of total sales. Bernas hinted that when the time is ripe, Marsteel could temporarily lower product prices, driving out smaller competitors who are unable to respond in like fashion.

Survey of producing firms. In a 1975 survey by the authors of local agricultural equipment manufacturers, producers of both IRRI-designed and independently designed equipment were interviewed. A total of thirteen firms were canvassed, eight in central Luzon near Manila and IRRI, and five to the south on Mindanao island. All eight firms in the north are currently producing or have produced IRRI-designed equipment. Seven firms are fabricating the axial flow thresher; three are manufacturing the power tiller. The batch dryer is produced by 2 firms, as is the plant seeder. Four of the firms have independently designed equipment for which they have obtained patents.

None of the five firms canvassed in Mindanao are currently manufacturing IRRI equipment although one firm had built a prototype of the IRRI power tiller, and two firms stated their intention to commence production in the near future. One entrepreneur in Davao has sold forty-seven units of a power tiller he himself designed. Four of the five firms are fabricating threshers which were designed by a native of Cotabato in the 1950s. In terms of sales, the power tiller has gained wide acceptance in central Luzon but is seldom seen in Mindanao. The small thresher, on the other hand, is popular in Mindanao but has received little acceptance in the north.

Eleven of the thirteen firms we surveyed can be classified as small-scale, with 4 to 32 employees. The two larger firms employ 150 and 1500 workers. The production facilities of most firms are relatively simple. In most cases the most expensive, sophisticated machine tool is the lathe; the majority of the work is accomplished with benders, grinders, selders, and drills. The one exception is Marsteel, which has facilities for molding, casting and forging. All producers have made some changes in the original designs, but Marsteel has extensively redesigned the IRRI tiller so that it can be fabricated with automated production facilities. However, it is only producing a few units of the thresher, which involves a more labor intensive process and is therefore too costly for the company's existing production facilities at the current level of demand.

Trends

There has been a strongly increasing demand for agricultural equipment in the Philippines during the past 7 years which can be attributed to the government's irrigation program, to the widespread adoption of high yielding varieties, and the shift toward more intensive cultivation of land. The country still relies heavily on imports to satisfy its requirements for farm machinery. However, local production more than tripled, and its share in total consumption doubled, in the period 1969-1973, increasing from 16% to 33%.

Table 1: Philippine Consumption of Farm Machinery and Equipment (in thousand pesos)

	Local Production		Importation		Total	
Year	Value	%Share	Value	%Share	Value	%Increase
1969	22,820	16	115,500	84	138,320	--
1970	39,350	23	131,730	77	171,080	24
1971	66,920	26	186,610	74	253,530	48
1972	58,450	22	206,160	78	264,610	4
1973	70,810	33	144,740	67	215,550	-19

A look at the structure of production costs for the past six years indicates that raw material expenses have grown sharply relative to labor costs. In 1968, 53.6% of manufacturing costs could be attributed to purchases of materials. This had moved up to 71% in 1973, due in part to increased prices of imports after the peso devaluation. Direct labor costs declined over the same period from 24% of total cost in 1968 to 12.4% in 1973. Manufacturing overhead also declined, from 23.8% in 1968 to 16.6% in 1973.

Ancillary industries within the Philippines remain relatively underdeveloped, however, Only the larger, more capital-intensive firms have facilities for castings and forgings. Supplies of local machine tools are also limited; a creative owner/operator may produce his own lathe, but the majority of the more sophisticated equipment is imported. The Philippines does have a capacity for steel production, but the quality of local steel is questionable.

Four wheel tractors. In 1973 the tractor population in the Philippines was estimated to be 14,000. The country does not have the capability to produce this equipment locally and is completely dependent on foreign sources. The most popular brand is the Ford tractor which accounted for 50% of total sales in 1973. Local content of the Ford tractor is minimal, averaging only about 1-2%. Tractor implements such as plows and harrows have a local content of 20%.

At the present time 47% of the tractors are used in the production of rice and 41% sugar cane. These statistics are useful when predicting future demand for tractors in the Philippines. D. N. Porter, for example, predicts slow growth in the near future, estimating that total annual sales will reach 1,500 - 2,000. This phenomenon can be explained by three factors. First, the needs of the sugar cane industry for tractors have been almost completely satisfied, and future demand, excepting replacements, will probably be limited. Second, the number of large rice farms — over 15 ha. — will decline as a result of Land Reform, and more farmers will opt for the less expensive power tiller. Third, demand for tractors by corn producers will probably be limited, due to the small size of most corn farms which makes tractor ownership uneconomical.

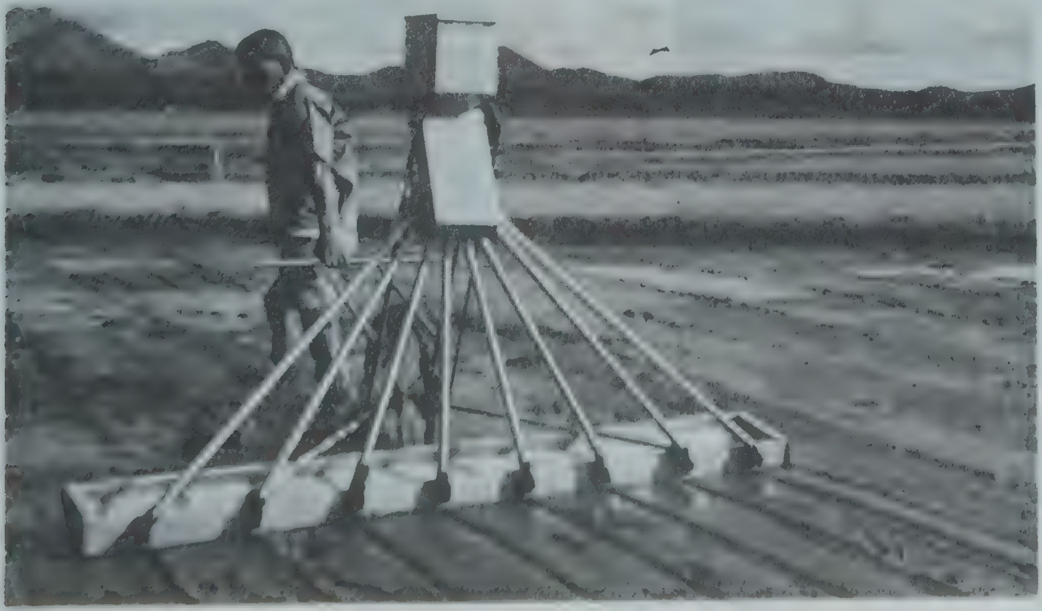
Power tillers. In contrast to tractors, the potential growth in demand for power tillers is considered to be high. In 1973 the tiller population was estimated at 8,000. The current market is for 5,000 units annually, conservatively projected to reach 10,000 units by 1980.

Until recently, the Philippines relied primarily on imports to satisfy its requirements for tillers. In 1972, for example, imports accounted for 85% of total power tiller sales numbering 1239 — i.e. 188 were locally made. During 1973, sales of tillers jumped to 2,456, and sixty-five percent of sales, or 1,609 units, were locally produced. Porter attributed this radical change to greater rural incomes and the availability of IRRI-type tillers.

Production in Other Countries

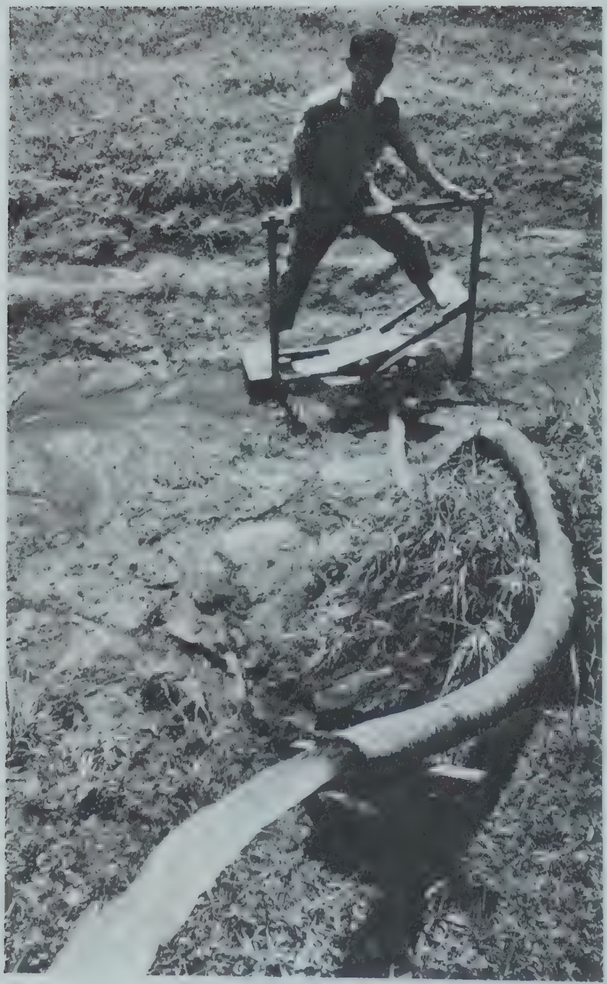
After production in the Philippines had begun, a program to promote the manufacture of IRRI-designed equipment in 10 Asian countries (India, Indonesia, Korea, Malaysia, Pakistan, Philippines, Sri Lanka, Taiwan, Thailand, and South Vietnam) was initiated. Under the provisions of this program, IRRI sends models of the equipment designed for Philippine needs to subcontractors in each participating country for testing and evaluation under the conditions in their countries. Subcontractors are usually research institutes, but in some cases business firms. Results of the tests are carefully recorded and returned to IRRI. By the end of 1973, 120 IRRI machines had been delivered free of cost for such tests with the hope that producers would become interested.

There have been a few successful ventures in Thailand, Indonesia, and Sri Lanka, but the program on the whole has been relatively unsuccessful. The IRRI machines may be mechanically sound, but the majority of subcontractors have not been able to provide market studies which could interest manufacturers in building them. A second reason for the limited success of the program arises from the lack of close contacts between the local manufacturers and IRRI technicians. Insufficient funding and manpower for the program have precluded active on-site participation by IRRI engineers, which in turn has impeded the production in the participating countries. Thirdly, native engineers often work in government research institutes which are relatively isolated from industry; they have little or no experience in working with technology to make it commercially viable. The AED is now concentrating its efforts on a formalized industrial extension program in Thailand and Pakistan, to overcome the problems noted.

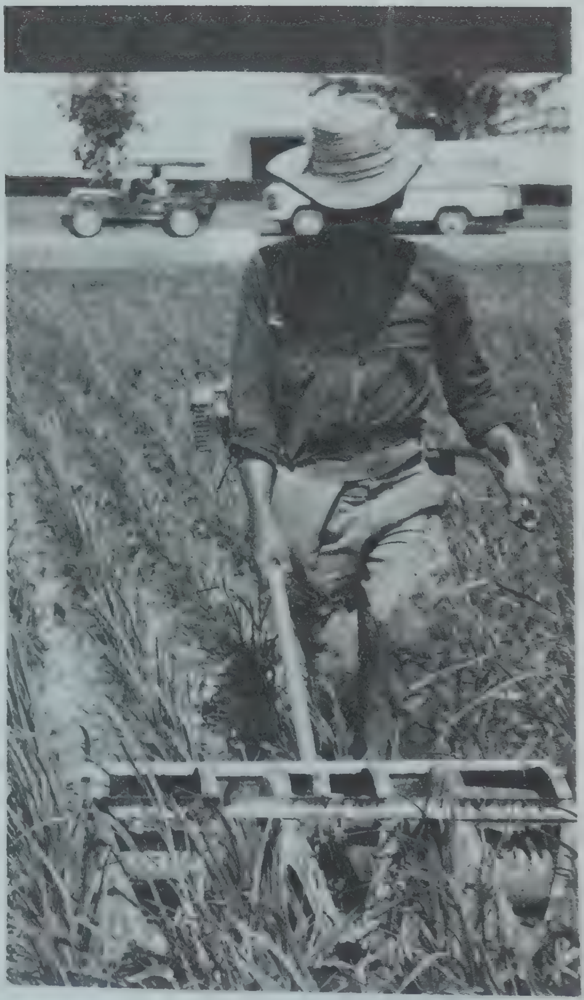


Seeder

RIGHT: Grain Cleaner



Foot Pump



Hand Weeder

Several Latin American countries have shown interest in IRRI designs. Field tests have begun on several types of equipment, and in a few cases machine shops have begun building their own prototypes for demonstration to farmers. A traveling exhibition of IRRI equipment will shortly be taken to Latin America.

Some Problems and Recommendations

The experience with introduction of IRRI-designs to machinery producers in the Philippines points to several problems not fully foreseen when the project was initiated, and which may also appear when similar production gets started in other countries. Some of these are the kinds of difficulties to be expected in launching any kind of "infant" industry making new, reasonably complex products. Other problems arise from the relations of small and large firms, given that IRRI technology is available without cost to all of them. A large firm like Marsteel, with ready access to credit, engineering skills and market outlets will, on the one hand, help to develop the market and encourage production by small shops, but will also retain advantages in the competition which ensues. It will be better able to buy materials and imported components in bulk at lower cost, to incorporate later innovations more readily, to market its machines more aggressively, and to cut prices temporarily to drive out smaller competitors. Large firms have less need for technical assistance from IRRI engineers whose time is limited. The larger firms are also joined in the Agricultural Machinery Dealers Association (AMDA) which can lobby for their interest; few small firms can affort its membership fees. It was not IRRI's intention to benefit big, powerful companies. A useful counter-move, therefore, would be the formation of a separate small-firm association, which could: establish a system of bulk purchase for its members; obtain technical assistance; run a clearinghouse of information on government contracts, export openings, and new technologies; and represent member interests in various quarters.

Concerning the role of government: the Philippine government has given priority in its current Four Year Plan to maximization of employment, more equitable income distribution, and the promotion of regional development — goals to which the localized production of small-scale farm machinery by labor-intensive, small shops could contribute. The government has organized a number of institutions to foster small business, and to get credit to smaller farmers (helping them to buy equipment among other things); and bank regulations are intended to follow the above priorities. But all such special institutions are necessarily limited in scope by funds, personnel, and often by their location in only a few areas. Regulations can only partly overcome the tendency of bank practices to favor the larger firms and farmers. In order to more effectively pursue the Plan priorities mentioned, and especially to reach the more remote areas, a network of multi-purpose provincial assistance and information centers could be of considerable value, both to the economy generally and incidentally to the IRRI program.

[Extracted from: 1.) The IRRI Small Agricultural Machinery Project, an unpublished study (still incomplete) by the authors and others for the U. S. Agency for International Development, 1975/76; and 2.) an unpublished study they made for the National Science Foundation. Much of this material will appear in a chapter of Technology Transfer and U. S. Foreign Policy, Praeger and Co., New York, publication 1976.]

MOTIVATIONAL TRAINING

WORK-ORIENTED ADULT LITERACY PROGRAM, ECUADOR (PHOTO: WORLD BANK)

Results of Motivational Training in Ecuador

James C. Frits

[Motivational training prepares its participants for development projects, makes them more self-confident and open to new ideas, helps them understand other people and work better with groups, and may furnish an important new factor in the development equation: these are among the findings of the evaluation study of a motivational training project of AID recently completed in Ecuador. The methods used in this training are briefly described.]

A search for unexplored ways to make development more effective began in 1967 when the staff of AID (the United States Agency for International Development) in Ecuador reflected on the frustration and disappointment that often follows development programs. Most planners have seen development as an equation that included capital, technology and organization-building. Most development assistance programs contained all three elements, usually with greatest emphasis on the first or second. Dr. Hayes Keeler of AID/Ecuador thought that another element might be included, one which centered around individual growth and changes in individual outlook and behavior. He suggested an equation of four elements: Capital + Technology + Organization Building + Individual Growth. Development was thus defined in a much broader sense than economic and technical progress embodied in roads, dams and factories. As Keeler put it: development is increasing the capacity of individuals to guide and influence the direction of their own lives. While this definition includes greater material well being, it also implies that individuals will increase their self-respect and understanding.

Dr. Frits is the Behavioral Science Advisor for AID in Quito, Ecuador.

Formation of Training Center

Beginning in the late 1960s, AID/Ecuador experimented with various kinds of training — behavioral, motivational, experiential — in a search for effective ways to bring the human development element into the programs it funded. By 1970 AID officials had become convinced that human motivational training was indeed an effective tool, judging from the reactions of participants in the training as well as from the results of an on-going sociological study. They felt, however, that such training would be more effective if it were carried out by an Ecuadorian organization rather than by foreigners. The Ecuadorian trainers who had been working directly for AID then organized a non-profit Ecuadorian corporation called CEMA (Center for Motivation and Advisory Services), and a four-year agreement was signed with AID to help the new organization find its role. By now AID has ended its support, and CEMA has become self-sustaining with contracts from Ecuadorian private clients and government departments along with the U. S. Peace Corps.

CEMA training. Because Ecuador is a country in which most of the rural people are not only illiterate but are held in subordinate positions within a strongly hierarchical system, CEMA emphasized the development of leadership qualities among villagers as well as in school teachers, health workers, and other urban-educated rural workers. CEMA trainers were and are bucking a traditional and oligarchic social and political structure which makes it difficult for the poor to obtain justice and participate in the material and other benefits of modern society. The traditional tendency of rural people is to look to the local "patrón," the government, or the church for the fulfillment of their needs, rather than striving to improve their lot by their own efforts. Motivational training was seen as a way to change this by changing the actions of rural people themselves. As individuals they may be relatively helpless; with the right kind of leadership, they could accomplish far more as a group.

CEMA trainers concentrated on skills that would help Ecuadorians in general, and campesino leaders in particular, to change their self-image. This involved "sensitivity training," a method of bringing a group of people not previously acquainted together for most of the day in seminars lasting one to two weeks, in order to get to know each other very well. In this way each trainee learns to understand other peoples' reactions to himself and how to manage his behavior in a group. (These are called T-Groups; some of the concepts used in this training were need-achievement, transactional analysis, and grid analysis.) The training also included "organization development," designed to help participants to form and sustain groups to accomplish various purposes. Later CEMA added training in a few other skills to suit the needs of specific clients.

The majority of CEMA trainees were "change agents," either local campesino leaders or people who worked directly with campesinos at the village level, such as social workers from the Ministry of Social Welfare or volunteers from Servicio Ecuadoriano de Voluntarios — a VISTA type of organization of volunteers. They received either one or two week motivational training seminars adapted to the needs of their specific project. Others who participated in week-long seminars were primary school teachers, principals and supervisors, university students, and normal school teachers. CEMA also organized shorter one-to-three day workshops for the Ministry of Health; between 1971 and 1974, these were offered to 484 village level health promoters, doctors, and paramedics, malaria eradication workers, home economics agents, nurses, social welfare workers and various health program community volunteers.

In general, the CEMA seminars tried to help participants become more accepting of change and better able to initiate it. As a culmination of the seminar experience, participants often wrote up a work plan to apply the techniques learned to their personal work style, and most seminars had later follow-up sessions to consider and revise the work plans. For instance, the campesino leader seminars provided practices in such leadership skills as discussion leadership abilities, communication skills, problem solving, decision making, collaboration with others, increased participation in programs, observation and evaluation. Teachers learned how better to introduce new teaching methods, health workers how to serve their community more effectively, etc.

Evaluation of Motivational Training Effectiveness

After three years of support to the new organization, AID officials wanted to know whether or not this type of training was meeting the goals which planners had set for it, and a study of the effect of CEMA training was commissioned in 1974. This study examined a stratified random sample of 86 respondents from the 1298 CEMA participants in three major categories: Education, Health and "Change-Agents," who had taken training between January 1971 and June 1974. (Change agents will be used from here on to designate local community leaders, plus non-rural workers in rural areas who had no conventional profession.) It also studied a modified control group of similar composition, and used post-test scores to determine differences between former CEMA participants and the control group. The data on the control group made it possible to compare CEMA-trained leaders with similar community residents who had received no such training. Data were collected using an interview schedule, partially unstructured, a time budget analysis, and miscellaneous supporting devices. Interviews were designed to find how much the training experience had influenced the attitudes of the trainees in particular ways, and whether it had actually helped them in their work.

Finding of the study. CEMA's goal was to serve the rural population indirectly by attempting to change the attitudes and behavior of potential leaders rather than those of the campesinos. A majority of the sample studied were well-educated, much better than the average of the Ecuadorian population: 62% of the ex-trainees had 12 or more years of education, while 22% had 7-12 years; only 13% had 4-6 years and 2% less than three years. More than half the ex-trainees were in positions that required at least a high school education (health workers, school teachers, principals, etc.). Nineteen percent of the sample were school teachers, 15% were school supervisors or directors, 35% were health workers, and 31% were change agents (as defined). The education level is important since, as will be seen, the change agents, who generally had the least education, showed the greatest effects from CEMA's training.

One of the most important factors explored by the study was human motivational training's effect on Awareness, a dimension the study defines as including a number of qualities illustrated in what follows below. It was found, for example, that training significantly increased Awareness in making participants more open to new experiences and ready to see more alternative possibilities in a given situation, and also in helping them think about democratic principles. Almost all indicators for Awareness, as inferred from analysis of the interview results, demonstrated higher mean scores for ex-trainees than for controls.

One indicator of Awareness is the degree to which an individual is willing to criticize his organization. More aware individuals have enough self-confidence to state openly their views about their organization or community and to make critical comments. Some 45% of the ex-trainees said they would criticize their organization or community compared to only 21% of the controls. The use of formal or informal address with colleagues is another indicator of Awareness. CEMA stresses a "climate of confidence," in which all participants are co-equal companions. They encourage the use of the familiar form of Spanish for "you" (tu) within the training groups, which included people of different social levels. 57% of the ex-trainees used this form as contrasted with only 41% of the controls.

To determine Awareness on an authoritarian-democratic continuum, ex-trainees were asked if they resolved conflicts by exercising their authority. Ex-trainees appeared to be more democratic in that fewer stated they resolved conflicts by exercising authority than did controls. Awareness on this authoritarian-democratic continuum is also indicated by the acceptance of others' ideas for making organizational or community decisions. CEMA ex-trainees scored much more strongly toward the democratic side than did controls: more controls (47%) felt it was necessary to make decisions on their own than did ex-trainees (30%).

Persons aware of alternative possibilities tend to believe they can personally affect their own destiny, i. e. dominate their environment enough to advance their own purposes or goals. To be innovative, an individual cannot be fatalistic and must feel he has some control over the future. More control respondents believed that government actions "are always more important" than individual efforts (35%) than did ex-trainees (17%). Particularly, ex-trainee change agents had little faith in the government's ability to carry out effective programs or projects. Fewer change agents (26%) believed the government can do better than individuals, while 45% of the educators thought so as did 43% of the health workers (the latter two were, of course, government employees). Similarly, the person who sees alternative possibilities is less likely to see opinions from a hierarchical or autocratic view. Instead of policy-making based on respect for tradition, the "aware" person favors discussion and constructive conflict. CEMA ex-trainees stated overwhelmingly (77%) that they "always" or "almost always" prefer discussion and conflict, compared to the controls (61%).

In general, the study found that CEMA motivational training made all ex-trainees more aware of their personal worth, have stronger feelings about what they can do as individuals, and be less autocratic than others. Among change agents there were dramatic differences between ex-trainees and their controls on four questionnaire items especially included to measure their application of these values to their methods of work: priority given to initiating work plans for community development; use of group dynamics in their work; emphasis placed on motivating people as a strategy to complete community objectives; becoming aware of specific skills one has (self-confidence) to complete projects. The study also explored the degree to which attitude and value changes appear in the area of work style. Ex-trainees consistently stated that work groups were more effective than working alone, while a majority of the controls would "always or almost always" put ideas into practice by themselves. Ex-trainees thought it was better to plan strategies and objectives through groups, and that it was important to participate actively in work plans of an organization or community. They felt they could learn work skills more easily with groups, and they had more positive attitudes about giving information to work organizations.

The study also points out that motivational training has a "halo" effect immediately after training terminates. Trainees felt immediately motivated; and many began to practice working in groups, tried new human relations techniques, increased their planning and organizational activity, began to provide more information to others. Other ex-trainees, however, said they were motivated but also frustrated. When they returned to a normal, traditional Ecuadorian work environment, many simply could not initiate, perform or otherwise use their CEMA training because they hold jobs with great restrictions and lack of opportunity. School teachers, in particular, felt great difficulty initiating new teaching methods which were not approved or understood by their principals or supervisors. Health workers, on an average, seemed to have more success than teachers applying their new skills since they often work alone in a community setting where they can change methodologies and techniques at will. Change agents had the greatest success applying their new skills. They usually work without supervisors, and generally with small groups, so that almost everything learned from motivational training could be readily applied to their work and goals.

A factor analysis of items on the study's structured interview confirmed the remarkable results among the change-agents. The action results of their training were greater when compared to health workers or educators, both of whom must work through bureaucratic organizations with strong cultural and official resistance to change. Whereas the ex-trainee health workers and educators scored higher than their corresponding control groups on 67% of the items relating to actions, the change agents scored higher on 90% of these items.

Considering the short period of CEMA training seminars and the great time lapse for many trainees between training and the study, its authors concluded that CEMA had been extraordinarily effective. However, the study could not find objective evidence that motivational training alone had led to social and economic change. It found the CEMA-induced human growth skills important as bases for developmental change and for the success of projects, but the effects of these new skills were often negated by outside forces such as cultural obstacles and intransigent bureaucracies. Nevertheless, it is clear from the study that development organizations have available to them a new tool to enrich their programs. The years of experimentation in Ecuador show that motivational training is a valuable aid, that its techniques can work with a variety of people in a variety of settings, and that it has in fact contributed to the successful outcome of a number of AID projects in Ecuador.

[Extracted from an unpublished
paper, September 1975.]

Note: As this issue was going to press it was learned that another version of this article will appear in the "Focus" portion of the International Development Review, and that Dr. Frits has been transferred to the AID Mission in Panama.

Sarvodaya Shramadana in Sri Lanka

A. T. Ariyaratne

[The Sarvodaya Shramadana Movement may be regarded as supplying a form of motivational training to its participants. Its methods are indigenous to Sri Lanka and Asian in origin, unlike the training described in the preceding article using methods originating in Western social science. The developmental objectives of the two methods have numerous similarities, though they are not identical.]

Sarvodaya Shramadana is a movement dedicated to a nonviolent social change based on the traditional culture of Sri Lanka. "Sarvodaya" means awakening or "liberation of all" and "Shramadana" is "gift of labor." Sarvodaya Shramadana calls on every person to use whatever mental and physical energy he possesses for the well-being of all. Such a movement has to work from the grassroots — from the village up. Already the movement which began with one village 17 years ago has extended programs to 600, and the target for the next three years is a thousand villages.

In each of these villages one or more youth leaders has voluntarily organized the community to carry out self-development. They keep in close touch with Meth Medura, the headquarters of the movement situated in the outskirts of Colombo, which coordinates all these activities on a national and international scale. Attached to the headquarters is the main training center for village level workers where at any time 300 young men and women are training in community leadership, agriculture, village technology, and all other techniques

Mr. Ariyaratne is Administrative Director and Honorary Organizing Secretary for the Sarvodaya Shramadana Movement, Moratuwa, Sri Lanka.

necessary for social change beginning at the village level. To date there are 1200 other youths in over 20 centers throughout the country engaged in a variety of cooperative agricultural and small industrial pursuits — all carried out on a basis of sharing and living a communal life.

Buddhist monks who have been respected for generations as the strongest social leadership force also have joined the movement in large numbers. There are six training centers for training monks to lead in village reconstruction. With these activities the Sarvodaya Shramadana Movement is by far the largest non-governmental development organization in Sri Lanka, bearing direct influence on at least 80,000 families. What is perhaps unique in the Sarvodaya Shramadana experiment is its conscious endeavour to harmonize the ancient with the modern. Sarvodaya was not built on preconceived ideas. It was a natural growth of a people who desired to develop by their own efforts, and who believed in greater participation in decision-making and implementation of programs that affected their lives. The experiences gained and lessons learned at each stage of the evolution of the movement provided its members with the resource material from which the ideology, the strategies, techniques and the organizational framework grew. Even today, with every new challenge, the Movement readjusts itself to achieve its target of building a new society from the village up.

Shramadana Camps

The path to this new society begins with the 'awakening' (Sarvodaya) of individuals, families, and village communities to their own potential. People come to understand they can make and carry out their own "development plan" to meet their own needs. They do not need to be mentally and physically dependent on what is handed down to them by distant bureaucrats and politicians.

Villagers wishing to be assisted by Sarvodaya are visited by Movement staff, and together they identify the most pressing need of the village that could be met by physical labor. This may be restoration of an ancient irrigation tank (water reservoir), the construction of a new tank, the cutting of a new road or the rehabilitation of an existing road, or any similar project. Sarvodaya then helps the village to organize a big Shramadana Camp to tackle this project, using local villagers, reinforced by other villages already involved in the Movement, and by Sarvodaya volunteers from towns and cities. A strict code of self-discipline is followed in these Shramadana camps with six to eight hours of each day devoted to physical work, and three to four hours of education through dialogue, song and dance.

The purpose of these Shramadana camps is to catch the attention of the villagers to demonstrate that some solutions to their problems lie in their hands (literally and figuratively). Various village organizations — a children's group, a young people's group, a mothers' group and a farmers' group — are created. Through them, villagers discuss with each other and then, if necessary, with the representative village council, their problems, needs and wishes, and together take whatever action is required.

Philosophical base. These groups also spend time discussing the Sarvodaya philosophy — a Gandhian philosophy which incorporates elements of Buddha (Buddhism is the predominant religion in Sri Lanka) and other major religions, as well as pre-colonial Sri Lanka rural culture. The major long-term goal is non-violent social change. The Sarvodaya approach is not ivory tower philosophizing but is based on very practical rural development actions carried out by villagers themselves, assisted by Sarvodaya's resources of workers, skills, facilities and funds and making use of the Government's assistance where available and relevant.

Shramadana camps lay the psychological infrastructure necessary for making people think, plan and work together. Groups in the community develop a social infrastructure that helps them identify problems pertaining to each group and plan solutions to these together. Development education institutes and training centers run by the Sarvodaya Movement help indigenous rural leaders, especially youths, to develop correct attitudes towards development and implement projects realistically and successfully. A revolving fund, called Gramodaya (Village Re-awakening Fund), advances loans to village groups on easy terms to supplement their capital needs. Excess produce from the village can find its way to national markets through the Sarvodaya Mini-Market in Colombo without the intervention of middlemen. Even international markets for their produce are open through the Sarvodaya Training System which has established links with world shops run by fraternal organizations in rich countries.

An ideological integration results from emphasizing the spiritual and cultural values in all programs. Meditation, traditional customs and ceremonies, and song and folk dances, form an integral part of Sarvodaya activities. Sarvodaya is a living, growing movement that each year attracts an increasing number of people. Sarvodaya believes that change in the world begins with change in countries; that change in countries begins with change in local communities; and that change in local communities begins with change in individual people.

Strategy for Change

1) In the developing world there must be a definite governmental recognition of the role of voluntary agencies, not only in providing social services but also in bringing about non-violent changes in the structures of society for social justice. The role they have to play may change from country to country, but participation is a must.

2) The political and economic power of the country must be decentralized to facilitate maximum participation of the people in the planning and the implementation of social and economic policy.

3) A complete overhaul of the book-centered, examination-based, socially fragmented, competitive educational system must be undertaken to make it meet the needs of the totality of the community.

4) While not causing any embarrassment to the sovereignty of the national government, the free movement of voluntary workers and material resources must be encouraged under the authority of national and international voluntary organizations which have proved their integrity, worth and non-commitment to political struggles. Perhaps the UN can undertake this responsibility by arrangement with national governments and enter into agreements to bring cooperation for self-development across ideological frontiers. The approach to cooperation between the voluntary organizations in developed and developing countries must not be confined to the exchange of volunteers. There should be an effective information exchange program concerning what prevents the poorer part of the world from developing, and a consistent effort by voluntary bodies in the developed world to press for economic justice for the poor world.

Development is not the product solely of assistance from the wealthy nations. As the Sarvodaya Shramadan Movement has shown, people in the poor countries can be mobilized to help themselves.

[Extracted from "A People's Movement Takes Hold," Cooperation Canada, No. 19, March/April 1975, pp. 24-29. Ottawa: Canadian International Development Agency.]

PRICING POLICY

A CONSUMER CO-OP IN LAGOS, NIGERIA
(PHOTO: INTERNATIONAL LABOR OFFICE)

Government Product Pricing in Korea

Gilbert T. Brown

[The prices fixed for products produced and sold by government enterprises are frequently important, both to consumers and to national development. This article examines pricing policies in four Korean industries — electricity, telephones, coal, water — and concludes that policies aimed at establishing market equilibrium prices are highly beneficial; contrary policies have been disadvantageous.]

Government enterprises are an important part of total economic activity in many developing countries, including South Korea. The privileged access they usually have to credit and saving via the government budget and the banking system, and their greater freedom than the private sector from market forces, can have important effects on prices, output, and the allocation of saving and investment. In addition, such enterprises often provide basic goods and services affecting the real incomes and welfare of lower-income groups, a fact which looms large in debates over their pricing, financing, and other policies.

The Korean government assumed ownership in 1945 of all Japanese-owned interprises, and it has retained some which have a public utility nature or a strong monopoly position. Among these is the Communications Special Account which includes the postal, telephone, and telegraph systems. The Korean government is also a stockholder in more than thirty "government invested corporations," most of which also have private stockholders. These firms include the Korea Electric Company, which has a

Dr. Brown is an economist at the
World Bank, Washington, D. C.

monopoly on the sale of electric power, and a corporation which produces 40 percent of the nation's coal. This article will discuss the pricing policies during the 1960s of the three enterprises mentioned, plus those of municipal waterworks. The industries selected illustrate problems in several different types of market, all of which have some national importance. The consequences of particular prices, and the pertinent social costs and benefits will be examined.

Collectively, the Korean government enterprises and government-invested corporations produced 6.5 percent of value added, 15.8 percent of national saving, and financed nearly 10 percent of gross national investment. Their savings (profits plus depreciation) have amounted to more than two-thirds of their own gross investment, with the remainder financed mostly from the government budget and by bank credit. Thus, these enterprises have financed from their own revenues a majority of the capital formation for railroad, electric power, telephone, telegraph, postal, and other government-invested enterprises. To do this, the prices charged for goods and services must be high enough to cover their current costs of production and beyond that to generate a substantial surplus of revenue to help meet investment needs. This policy is in marked contrast with the experience of a number of countries where many such government-owned enterprises operate at substantial deficits, so that significant sums of general government revenues must be used just to meet these deficits, and where new investment must be financed by further government expenditures and by borrowing from the private sector.

Korea Electric Company

The Republic of Korea was short of electric power from the time of the division of the country in 1945 until the early 1970s. In 1946 and 1947 South Korea purchased two-thirds of its total electric supply from North Korea, but that supply was cut off in May 1948. Power barges with diesel generators, small diesel generators for individual users, and other equipment was hastily purchased and borrowed to meet this crisis. Supply seemed momentarily to have caught up with demand for the first time in 1965, but this illusion was quickly shattered when an easing of restrictions on the use of electricity and rising levels of income produced an outburst of new demand that soon led to renewed "brown outs" and power shortages that threatened to stifle economic growth. Given this chronic condition of short supply, the basic decisions in electric power have been those of pricing and investment.

The basic priority of the power program during the 1960s was to expand generating capacity sufficiently to meet the power and lighting needs of industry and commerce, and secondarily to provide for a steady expansion of household lighting service. Rural electrification programs made some progress in bringing service to farm and fishing villages, but the high investment cost per revenue yield on such service caused this program to move relatively slowly before 1970 because of the intense competition for investment funds for other uses.

The pricing structure of electricity is consistent with these allocation priorities, with lowest rates for irrigation and large power service and highest rates for households. Except for irrigation uses, however, these relative prices also tend to reflect differences in the relative costs of providing electricity to these alternative users. Since 1961, however, the price of high tension service to large industrial users increased by 81 percent, compared to 36 percent for regular service to smaller users. Special discounts are given to those using power to produce exports, to producers for whom electricity accounts for more than 20 percent of the cost of production, and to municipal water companies.

Two crucial decisions for future power development were made in 1961 which set policies for the decade. The first was to raise electricity prices by 50 percent to create profits from which to finance the expansion of the electric supply, and to encourage economy in consumption. The 1961 price increase was followed by another 50 percent increase in 1964, and smaller increases in 1966, 1967, and 1969 (table 1). The second 1961 decision was to merge Korea's three electric power companies into one company, the Korea Electric Company (KECO) to achieve operating and managerial efficiencies. These actions shifted the electric company from a deficit to a profit position. In constant prices, the price of electricity rose about 10 percent between 1960 and 1962, while its cost of production and distribution declined by 40 percent; between 1962 and 1970 it fell by another 50 percent. The reduced costs reflected the establishment of a nationwide electric distribution grid, system-wide planning, reduced managerial overhead, and expansion of lower-cost categories of service.

Electricity pricing has been important because the critical problem restricting the expansion of generating capacity throughout the 1960s has been lack of financial resources. The cost of equipment could have been financed through foreign borrowing, but borrowing for power generation would have reduced the availability of foreign credit for other purposes. The domestic currency (won) costs of site preparation and plant construction were also considerable. KECO's prices since 1962 have generated profits equal to one-fourth to one-third the value of sales, and a ratio of profits plus depreciation equal to more than one-half of value added. Annual profits plus depreciation during 1964-68 amounted to 30.5 billion won (in current prices), of which 3.3 billion won was paid in dividends to private stockholders. The remainder was available to finance new investment. The total won and foreign exchange cost of additional generating facilities completed during that time, which increased installed capacity from 465,000 KW to 1,274,000 KW, or by 174 percent, was only 47.8 billion won. Thus KECO's gross savings were more than 60 percent of the total cost (and 173 percent of the won costs) of this newly completed capacity.

The rapid growth in industrial production after 1965, as well as increased nonindustrial use, resulted in a far more rapid increase in demand for electricity than had been thought possible. Increased availability of electricity caused small industry to increase its electricity use by about 35 percent per year. Total electricity sales, which were limited by supply rather than demand, grew at a 27 percent annual rate during 1967 and 1968, compared with only 14 percent during 1955-61 and 19 percent during 1962-66. The proportion of

Table 1. Korea Electric Company Data[a]

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
Percent of rate increases, current prices		50%			50%		25%	15%		10%		
Rated power capacity (thousand KW)	367	367	434	465	597	769	769	917	1,274	1,636	2,508	2,628
Power sales (millions of KWH)	1,136	1,213	1,508	1,683	2,035	2,452	2,989	3,883	4,850	6,358	7,740	8,884
Lighting	235	228	266	292	350	417	494	563	656	827	1,009	1,231
Power	901	984	1,242	1,391	1,684	2,035	2,495	3,320	4,195	5,530	6,731	7,653
Operating costs per KWH (1965 won)	8.0	6.7	4.8	4.3	3.1	3.2	3.2	3.2	3.2	2.7	2.4	2.5
Electric operating profits[b]	570	1,721	2,293	871	1,806	3,734	4,471	4,966	5,652	6,848	9,203	7,087
Revenues[b]	9,616	9,878	9,514	8,047	8,135	11,641	14,329	17,468	21,035	23,913	27,656	28,943
Expenses[b]	9,045	8,157	7,220	7,175	6,328	7,907	9,587	12,502	15,383	17,065	18,453	21,856
as a percent of sales[b]	5.9	17.4	24.1	10.8	22.2	32.1	33.1	28.4	26.9	28.8	33.6	24.7
Profits, all operations[c]	- 439	645	1,483	862	1,169	2,822	3,180	3,887	3,750	3,966	5,526	2,814
Depreciation	n.a.	n.a.	n.a.	n.a.	1,541	1,775	2,460	2,518	2,723	3,399	3,646	3,866
New investment in generating capacity by year of project completion	n.a.	n.a.	4,658	2,651	8,262	12,512	0	6,118	14,287	8,320	18,432	12,004

Sources: Data from *Korea Statistical Yearbook, 1971* and earlier years, and *Economic Survey 1969*, both published by Economic Planning Board; *Financial Statements Analysis 1967* and *Financial Statements Analysis 1960-1966*, Bank of Korea, and Korea Electric Company.

a/ Figures are in millions of 1965 won unless otherwise indicated.
b/ Excludes street railway operations (which ended in 1968), and nonoperating revenues and expenses.
c/ Includes street railways and nonoperating revenues and expenses.

electricity going to smaller industrial users fell from 14 percent in 1960 to 9 percent in 1967, while the share to large industrial users, such as cement plants, rose steadily from 64 percent of the total in 1960 to 75 percent in 1967. Household consumption and other lighting was allowed to expand, but less rapidly than the growth of capacity. The number of household customers doubled between 1960 and 1967, however, and rose by another 7 percent in 1968. Furthermore the quality of household service rose as those receiving flat rate service (100 watts of attached power, or three weak light bulbs) fell from 62 percent of the total in 1960 to less than 6 percent in 1967. By 1968, most urban dwellers had electricity, but two-thirds of rural families did not because of the high costs of providing such service.

Higher average electricity prices produced important welfare benefits because of their role in increasing the overall level of saving and bringing the supply of electricity closer to the quantity demanded. The increased power supply made possible by the saving generated by higher prices permitted industrial production and employment levels to rise considerably more rapidly than they otherwise could have. Between 1964 and 1970 electricity sales increased by 3. 8 times, constant-price operating costs declined by 23 percent, and saving from electricity operations (operating profits plus depreciation) increased by 3. 8 times. These savings in 1970 were equal to nearly one percent of gross national product. While the welfare consequences of such a change cannot be measured directly, there are substantial benefits to offset the welfare loss from reduced consumption that may have occurred because of higher prices. This is particularly true because any tendency toward reduced electricity consumption by lower-income groups due to price increases was at least partly offset by the increased saving and investment, and the lower real cost and price of electricity and its increased availability over time, both of which served to increase the consumption of electricity by lower-income groups.

To have diverted more of the existing supply of government resources and/or bank credit to financing for KECO would have reduced the growth of investment in other areas. To have gone the alternative route of additional government deficit financing would have further inflated the money supply, which would almost certainly have further increased the rate of inflation and slowed the growth of private saving and of government revenues. The only other option would have been to have used more foreign saving, as was done to meet the requirements for investment in electricity in 1967-68; but the limit to a country's foreign debt burden would also have meant that less foreign capital would have been available for other uses.

It could be argued that prices of electricity should have been even higher than they were, at least prior to the appearance of excess capacity in 1970-71. Many potential users who could not obtain service would have undoubtedly been willing to pay somewhat higher prices in return for increased service. A higher price (up to the short-run equilibrium level) would not have meant reduced total consumption, but would have perhaps reduced consumption by some users offset by increased consumption of others until such time as new investment increased the total supply of electricity and lowered its costs. Higher prices would, of course, have meant yet more internal saving and less domestic or foreign borrowing.

There are no meaningful data to measure the effect of price increases on demand for electricity. The shortage of supply determined the total volume of sales, and rationing devices as well as price differences affected the distribution of sales between customers. There is definite evidence that prices have been high enough, however, to curtail many demands. One is the relatively low level of lighting in Korean factories and places of business, as well as homes. Also, the low-power-consumption neon tube is much more common than the ordinary incandescent light bulb, since its higher initial cost is quickly offset by the savings on electric current. Also, the high price of electricity for household use has so far prevented any very widespread demand for household appliances such as electric irons, air conditioners, fans, toaster, and the like, especially the high-wattage items. There is demand for electric washing machines, for example, but none for electric clothes driers. The same economizing on use of electricity is seen among industrial and business users. Expected electricity requirements have been one factor considered by the Economic Planning Board in approving applications for foreign financed investments.

Telephone Service

Demand for telephone service in Korea has always outstripped supply, and there is an active black market in the sale of telephone service. The waiting list for telephone installation is long, and the time between the request for service and its installation is normally one to two years or even longer unless one resorts to the black market. The black-market prices for prompt installation in Seoul are published regularly by a Seoul newspaper, and are generally about one and a half to two times as high as the official charge. Published data on the Communications Special Account are inadequate to make an estimate of profit and saving on telephone service alone, since the entire postal system, telegraph system, and part of the radio system are also part of the same special account. This special account has been operated on a net profit basis. Domestic telephone revenues constitute about 40 percent of total revenues of the account, and telephone service is believed to be its most profitable operation.

Telephone prices have been increased less often than those for electric power, and have remained well below market equilibrium. Customers and the general public would probably have benefited from higher telephone installation and service charges in the 1960s. The increased revenue from prices closer to the short-run equilibrium level would have provided additional saving to speed up the installation of additional switching offices, lines, and individual telephones. The public could have had more extensive and better service, and there would not have been as much delay and payment of bribes in order to get service. The actual cost to customers of installation charges closer to the market equilibrium price would have been very little: a near doubling of official installation charges in 1968 had almost no effect on black market prices for immediate installation. At the end of 1968 these were 150 to 200 percent of the official price, compared with 250 to 375 percent a year earlier.

The reasons most often given for not raising telephone prices were to keep down the cost of service for lower income groups and to help fight inflation. Neither reason is convincing. Many and probably most middle-income families could not afford even the official installation charge, which in Seoul in 1968 was 90,000 won ($300), or nearly twice the per capita GNP. Thus the practical question is one of access of middle-income families, not lower-income groups. The installation charge seems high in comparison to the 4 won charge per local call. The low per-call charge permits low rates on public telephones, and thus lends some air of credibility to the argument for keeping prices low for low-income groups. But unless one has rich friends or relatives, the phone is useful only for calling larger business establishments or government offices, which poor people do much less than their richer neighbors. It appears that middle-income groups would benefit from higher per-call charges for phone service and the resulting use of the additional revunue to expand phone service. More rapid expansion of phone capacity has been a prerequisite to making more service available to moderate-income groups, since this is a decreasing cost industry and demand has consistently exceeded capacity at existing prices as reflected in the black market prices.

Coal and Coal Briquet Prices

Briquets made from coal are Korea's principal heating and cooking fuel in urban areas. Government attempts to control the price of coal briquets, at less than short- and long-run equilibrium levels have caused a welfare and economic loss in the last half of the 1960s to consumers (particularly low-income families) and coal miners, reduced national saving and investment, and caused damage to the coal industry and to Korea's balance of payments. In May 1961 the government imposed price ceilings on private as well as government coal mines. After rising costs led to the closing of many private mines, the government removed price controls on privately produced coal in mid-1964 and a few months later raised prices of government-mined coal. Price controls were retained, however, on the 11 pound briquets that were virtually the sole household fuel. More than half of total coal production went into making briquets, and it was argued that their prices were too politically sensitive to permit larger increases and that it was necessary to "hold the line" on briquet prices to help fight inflation and protect lower-income groups. The unfortunate consequences of attempting to control briquet prices in the face of rising coal prices, however, were many.

Briquet makers reacted to price controls and the profit squeeze in several ways. First, they reduced the quality of their briquets by using more clay and less coal. Consequently more briquets had to be used per day to provide the same heat, and it became more expensive to use the poorer quality briquets than it would have been to pay a market equilibrium price for briquets of the previous quality. Second, during much of the spring and summer of 1966 briquet makers refused to buy coal or manufacture, creating a backup of coal at the mines and the threat of a fuel shortage. Third, once the crisis became evident, dealers ignored the 8.5 won per briquet price ceiling and the typical going price became 15 to 16 won apiece, and in some areas higher. In October the government partially acknowledged the situation by raising the ceiling price to 12 won.

The government then tried to depress coal and briquet prices by increasing the supplies of available coal. To deal with the threat of a fuel shortage in late 1966, the railroad gave top priority to moving coal, even at the expense of costly delays in moving other commodities, including badly needed lime for the barley crop. Second, the government tried to channel as much government-mined coal as possible to briquet manufacturers because its price was cheaper than that of privately mined coal. The Korea Electric Company was ordered to use oil rather than coal in all generating plants capable of burning either fuel, even though this increased the fuel cost of these plants by at least one-third. Because delivery costs were higher to smaller users around the country than to power plants, and its coal was sold for the same delivered price in all locations, the government coal company became a deficit rather than a profitable operation. Furthermore, the government imported duty-free from Japan large numbers of kerosene space heaters and encouraged the use of other oil heating equipment, imported large quantities of heating oil to meet immediate needs, and began drawing up plans for much of the future increase in fuel needs to be supplied from expanded domestic refinery capacity as well as direct imports.

Because of the greater convenience and cleanliness of oil heat and the uncertainties about the availability and price of briquets, most middle- and upper-income families bought the petroleum heaters for use at least in the spring and fall when the demand for heat is intermittent. These households have also kept their briquet-burning facilities, however, and continue to use these during the winter, when the need for heat is sustained and use of briquets is cheaper. The heating of large auditoriums and other facilities with only intermittent demand for heat has also largely shifted over to oil. Lower-income families, however, have generally continued to use briquets for all heating.

Government coal mine saving as well as profits have been negative in the years 1967 through 1970 due to prices often 20 percent or more below those of private mines. Therefore all investment and some operating expenses of government mines have had to be met from the government budget and from bank loans. As a result of increased competition from petroleum fuels, coal production fell by 17 percent in 1968, then remained at the lower level through 1969 before recovering to the 1967 level. This created considerable unemployment and hardship in coal regions. To encourage more coal mine investment and production, and to slow the growth of oil imports, the government increased the import duty on "bunker C" fuel oil from 5 percent to 10 percent in 1969, with the additional revenue earmarked for coal industry investment or subsidies. It has been a net loss to the economy to import oil for purposes for which domestic coal supplies are a cheaper and close substitute.

The welfare effects of government efforts to maintain coal and briquet prices below short-run equilibrium levels in the 1960s have almost certainly been negative. Lower-income consumers, for whom it was desired to keep briquet prices low, have been worse off because price controls actually raised their fuel costs by bringing about a lowering of the quality of briquets and (for several years) adding to their price through a scarcity value arising from uncertainty of supply. National savings were lowered by the deficits experienced by the government coal company, by higher fuel costs for KECO, and diversion of government revenue and bank credit from other productive uses to cover operating losses and finance new investment. Briquet dealers probably found their incomes increased in the short run as they raised their prices well above official ceilings, but in the long run have seen the volume of their business decline. National product was lowered and coal miners found themselves unemployed, even though they were producing an economically competitive product, because of government actions requiring certain consumers to use higher cost petroleum fuels, and because all petroleum and oil heating equipment was imported without tariffs or at very low tariffs, thus at a lower than average exchange cost for imports.

Municipal Waterworks

Seoul, Inchon, and Taegu, three of Korea's major cities, undertook extensive water and sewage expansion projects during the last half of the 1960s. In these and other cities water and sewage facilities are owned by the municipality. Foreign loans were obtained to finance the cost of imported filtration, pumping, and related equipment. Other investment funds were obtained from government budgets and to a modest extent from bank loans. In each instance, however, water and sewage charges were raised in order to service all new debts and to generate funds for planned additions and replacements to these plants and ancillary facilities, including booster stations and additional storage facilities as well as pipes and pumps. The health benefits of good water and sewage facilities are so great that it can be argued that these facilities should be provided at a subsidized price in order to get universal use. The least costly way to increase the number of users, however, would be to charge prices adequate to cover the opportunity cost of capital and to use those profits to extend water supplies to urban areas (mostly low-income) currently without municipal water and sewage.

One interesting twist to the pricing schedule of the Seoul Water Bureau was that the basic household rate for water is the lowest per cubic meter rate for any users. In an August 1968 increase that raised overall water rates by 36 percent, rates for large water users were put on an ascending schedule, with monthly use in excess of 1,000 cubic meters being charged three and one-half times as much as the flat cubic meter rate of households. Smaller nonhousehold users pay a flat rate that is 50 percent higher than for households. Thus, an overall deficit in the cost of service is avoided, with larger users subsidizing lower rates for households and small-scale business users. Aside from possible welfare judgments, an increasing marginal price for large users is contrary to normal economic thinking and reasoning, since the cost of service to large customers is lower. This pricing system may have a sound economic justification, however, since it discourages large water users from locating in the Seoul area where water usage nearly equals the presently available supply, and where the capital cost of increasing the water supply would be quite high.

Conclusions

For the enterprises reviewed, prices have been sufficient to cover current operating costs with the exception of coal in the middle 1960s, and varying amounts of surplus revenue were obtained which helped to meet investment needs. In assessing Korean pricing policies, it must be remembered that annual rates of inflation averaged 15.2 percent from 1960 to 1970, so that price increases were necessary just to keep up with rising costs. The price policy decisions noted above were nearly always to raise prices beyond the current rate of inflation. Since all enterprises concerned were selling in markets where shortages of supply relative to demand could be observed (aside from electricity in 1970), the decisions to increase "real prices" were decisions to bring prices closer to equilibrium levels. It would appear that excess demand was never wholly eliminated (with the brief exception noted), as shown by capacity operation of plants, black markets, administrative rationing, etc. Nevertheless, the policies pursued were generally in a beneficial direction, for reasons specified in each case, and where there was movement away from market equilibrium in the case of coal briquets there was a net loss in welfare as a result.

Analysis of the pricing policies in four quite different markets strongly supports the conclusion that government enterprises should set the prices of their goods and services at levels that approach or approximate estimated short-run equilibrium prices. (This analysis is not intended to apply to basic governmental services or to education, which are generally best financed by taxes. Rather it is intended to apply where the enterprise is supported primarily by the sales of its products.) This means setting product prices at levels that will yield a rate of return on the capital used in their production comparable to that obtainable in alternative uses. Korean pricing changes in the period covered were quite consistently in the direction of moving toward opportunity cost prices, and thus the levels to be expected in the "perfectly competitive markets" world of economic theory in which such pricing maximizes total income by causing each factor of production to be used in that activity in which its productivity is the greatest. If the price charged for a product is less than adequate to yield the "opportunity cost" rate of return on its cost of production, this implies (among other things) that such a price is too low to generate adequate investment in its production.

To summarize the benefits of this policy: increases in product prices to bring them much closer to equilibrium levels resulted in increased national saving and investment, a more rapid rate of income growth per unit of investment, an improved balance of payments position, less inflation, lower costs and prices through increased output (i. e., greater economies of scale), and benefits to consumers generally and particularly to lower-income groups. Subsidized pricing has proved to be a grossly inefficient way to benefit lower-income groups, who got only a small portion of the outlays for such subsidies. Important administrative benefits were also obtained by raising prices toward equilibrium levels: it reduced demands upon administrative talent, one of the scarcest of developing country resources, to make specific allocation decisions among competing consumers. Another benefit was to reduce bribery and corruption by reducing the number of situations in which an administrator could control the access of a specific consumer to a desired good, service, or factor of production. Also, closer to equilibrium prices made it possible to estimate much more accurately the equilibrium level of demand for specific marketables, and therefore to make better investment decisions and a more efficient use of investment resources.

The benefits of the savings generated in government businesses have been most obvious in the rapid expansion of basic infrastructure and other productive capacity which they have financed with relatively little demand on the government budget or the banking system and private sector saving. This is in marked contrast to the financial position of government businesses in many developing countries, where such enterprises often absorb an important part of tax revenues to cover operating deficits as well as investment costs. Raising a government enterprise price to bring it closer to an opportunity cost increases profits and savings (or reduces dissaving) for both the enterprise and the economy. This increase in enterprise and national saving creates the possibility of more investment in producing the product whose price has been raised when demand still exceeds supply at the higher price, or when there are important cost-reducing benefits. This has been the consequence in Korea of higher prices for electricity, telephone, and water services.

The usual argument against raising the prices of government-supplied products, which is a highly political decision in many cases, is that it hurts consumers, especially those with lower incomes. The higher price initially means reduced real purchasing power and income for consumers, but this is a temporary effect which is soon offset. Consumers necessarily readjust the use of their income, buying less of either the commodity whose price has been increased, or of some other commodity, and possibly saving slightly less. Consumers as a whole soon have greater real incomes than they would have had without the price increase, however, as the resultant increase in saving and investment increases levels of employment and output. The evidence in Korea is that it is the wage earners and lower-income groups who suffer most from less than full employment, and shortages of goods.

Looking specifically at the effects of higher prices in the cases reviewed above, lower-income groups probably benefited most from the increased supplies of electricity and water, whereas the effects of the prices of coal briquets and telephones are more questionable. It is not realistic to think that these or other goods and services are going to be more accessible to lower-income groups just because their prices are lower. As long as there is a scarcity demand, higher-income groups are going to satisfy their demands, even if it means paying black market prices for telephone service, for coal briquets, or whatever is in short supply. The increased capacity of the electric company, for example, has done more than price subsidy schemes or any other measures could possibly have done to provide electric power as well as jobs to lower-income groups. The fivefold increase in generating capacity between 1962 and 1970 could not have occurred without electricity price increases unless other investment had been cut back and economic growth slowed, and the expansion of capacity has been accompanied by a halving of the constant-price costs of production and electricity prices. Lower than opportunity cost telephone prices have not helped lower-income groups, since the result has been a black-market cost far above the official price. Low briquet prices have meant a lower quality product and therefore more expensive heating, even without taking account of higher than controlled prices.

These strong conclusions about price policy for these products do not necessarily mean that the pricing policies in question could not have been improved upon, as has been noted. What it does mean is that increasing prices to more nearly their competitive market equilibrium levels, and therefore covering at least a substantial part of their opportunity cost of production, has been very beneficial to growth and to consumer welfare.

[Extracted from Chapter 4 of Korean Pricing Policies and Economic Development in the 1960s. Copyright ©, The Johns Hopkins University Press, Baltimore, Maryland, 1973.]

Rice Price Policy in the Philippines

Leon A. Mears and Teresa L. Anden

[Many governments undertake to control the price of their basic food staple, such as rice in the Philippines, in an effort to encourage producers and simultaneously protect consumers. This article describes the complex requirements that must be met for successful application of such a policy under Philippine conditions.]

Over the past 20 years the Philippine Government has been actively engaged in programs to support a floor and control a ceiling price for palay (unmilled rice) and rice (milled). Under the 1966 law, rice producers were guaranteed a floor price of not less than P16 per cavan of palay and consumers a price ceiling not greater than P1.40 per ganta of rice, but these prices became unrealistic with the imposition of the floating exchange rate in 1970. (The ganta is about two kilograms; the cavan equals 44 kilos of palay or 56 kilos of milled rice. Current value of the Philippine Peso: 7P = US$1.) The rice price spiral that followed in 1970/71 is only the most recent evidence of the continuing desirability for implementing the price stabilization function by an appropriate agency of the government. Other economic reasons include: 1) the large annual price fluctuations, far exceeding holding costs, that have occurred frequently at both farm and retail levels, 2) the evidence of several persistent inter-regional disequilibria in excess of transport costs, and 3) the emphasis by rice millers on trading profits at the expense of efficient management of processing activities. Further, there is overwhelming

Dr. Mears is a Professor of Economics at the University of Wisconsin. Dr. Anden is with the International Rice Research Institute, Los Baños, Philippines.

evidence that existing legal guidelines have lacked sufficient flexibility to permit effective implementation under continually changing conditions. They also have not sufficiently delineated general policy objectives to guide administrators toward synchronization with other development objectives and corrective action where market performance is inefficient.

Elements of a rice price policy. In its simplest effective form, rice price policy must satisfy the following Government objectives: 1) provide a price stability of this basic staple in line with the needs of uninterrupted development; 2) support a floor price that will appropriately stimulate production; 3) control a ceiling price that will assure rice at reasonable prices for consumers; 4) permit a seasonal range between these two prices to cover costs of holding stocks between harvests (including a premium for risk); 5) provide suitable relationships with other domestic and world prices; and 6) minimize Government implementation costs, taking into account the social and other Government objectives.

In terms of marketing efficiency these policies imply: 1) seasonal price increases commensurate with holding costs, 2) inter-market price differentials commensurate with transport costs, 3) processing costs commensurate with those possible with effective management, 4) a marketing system conducive to the introduction of cost reducing technology, and 5) domestic/world price relationships commensurate with the degree of self-sufficiency and the consequent export or import imperatives.

To satisfy these criteria will require strict financial and managerial discipline. However, similar policy objectives have been successfully implemented in other countries in Asia where the development was less advanced than in the Philippines. The only precaution would be to ensure that the specifics of the policy were realistic to the Philippine situation. They should take into consideration constraints relating to transportation, weather, processing, storage, cultural characteristics and organizational and financial capacities. These are discussed along with suggested procedures for determining relative prices within the policy guidelines.

Determination of price levels. Price determination can appropriately begin with the establishment of a floor price at bodegas (government buying centers) that will bring forth the desired production response. Determination of this price level should take into account the effects on hectarage planted in rice (and on yield), and on the use of modern yield-increasing inputs, of a change in the palay price relative to other prices. Studies of the price elasticity of hectarage planted by Dr. Mahar Mangahas can provide guidelines concerning hectarage and also the resulting yield changes, but subjective evaluation must be relied upon to judge the effect of expected palay prices on increased input use.

With the price structure of palay relative to other goods that existed in the late 1960s, together with credit provision and other support to farmers through the rice intensification program of the National Food and Agricultural Council (NFAC), increased input use was induced with resulting increased yields. Total output appears to have been close to the self-sufficiency level in 1970. So, a floor price at harvest that would at least maintain for the 1971/72 harvest the late 1960s terms of trade for the farmer would appear to be an appropriate first approximation. A first approximation for such a floor price for the Central Luzon region would approximate P21.50 per cavan of palay ordinario in 1971. (If inflation persists, further adjustments would be required.) This price should be announced several months ahead of each major planting season and maintained through the related harvest if it is to have the desired effect.

The time may be approaching when the guaranteed floor price can be reduced relative to other goods. The profitability of modern technology with improved seed is by now widely recognized in the Philippines. At 1971 fertilizer prices and a palay price of P21.50/cavan, expected incremental benefit/cost ratios are in the order of 3 to 1 for incremental fertilizer application of up to 90 kg. nitrogen/ha. (compared to no fertilizer use). Such ratios far exceed those necessary to attract and hold farmers with assured water supply to high-yielding seed and the modern inputs required. When the self-sufficiency objective is realized, the higher income generated by this technology can be transferred to other investment to the extent the floor price can be lowered and still induce production at a level to balance demand at the related ceiling price. To continue unnecessarily high price supports would tend to discourage the spread of modernization to a diversified agriculture. It also would perpetuate — without reason — the regressive income effects arising with the affluent farmer being more apt to have the irrigation which provides greater probability of realizing larger benefits from the new technology.

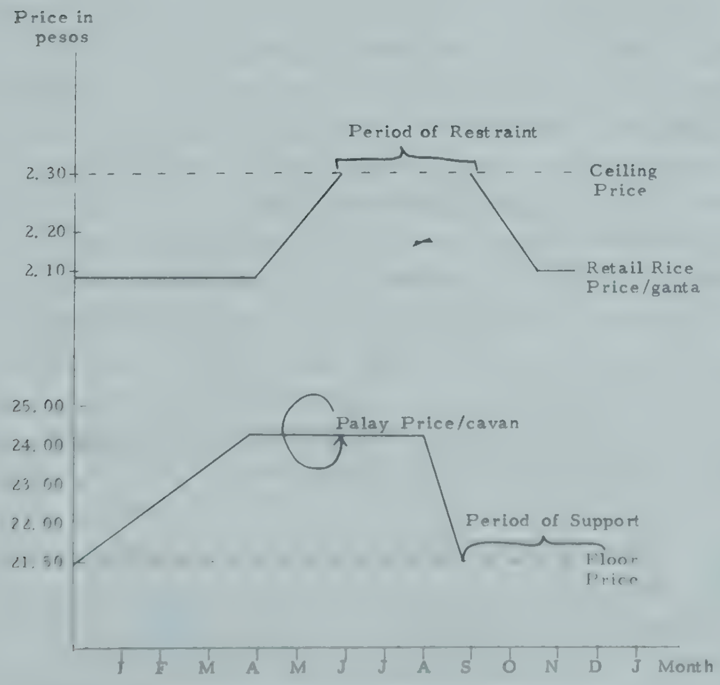
Given the historical average marketing margin in the Central Luzon/Manila market between 1958 and 1969 of approximately 25 percent from farm to retail, this floor price would lead to a retail price in Manila at harvest time of P2.08/ganta of "Macan" 2nd class rice. The retail price later in the year must be sufficiently higher than the harvest-time price to allow for costs and risk of holding for 4 to 5 months. This would require a 10 percent rise, or a ceiling price before harvest of approximately P2.30/ganta. It is important that this range allow for full storage costs as otherwise Government operation will have to displace private storage, with responsibilities and financing that the Government is probably not desirous of assuming.

As production nears self-sufficiency in the Philippines, this retail price seasonal range should include the world price to enable importation or exportation as may be required with greatest overall advantage. The center of the range indicated above would correspond to an FOB Manila price of approximately US$145/ton on ordinary quality rice, 35 percent broken. This is almost double the 1971 export price for equivalent quality from either Thailand or Burma. The suggested price level therefore would prove profitable only for imports but would require a heavy subsidy for exports. This potential profit from imports explains why continued isolation of the domestic from the world market is necessary; unprogrammed imports by the private sector could interfere seriously with floor price maintenance. Uncertainty both as to production response and world price levels gives emphasis to the need for flexibility in legal price policy directives.

The seasonal pattern of retail rice and farm palay prices that might be expected in the Central Luzon/Manila region when maintaining the above floor and ceiling price limits is illustrated in Chart 1. The agency administering this policy for the Government would be expected to purchase at the floor price all quantities of palay offered at that price by the farmers and to inject rice in markets of major urban areas as required to keep the retail price below the ceiling.

CHART 1

Expected Seasonal Pattern of Rice and Palay Prices under Price Controls (1970/71 Prices)



Source: Basic Price Data: Farm prices, DANR, Bureau of Agricultural Economics; Rice prices, Bureau of Commerce, Manila

Spatial price dimensions. The retail ceiling price level at major rice marketing and population centers outside Manila should correspond closely to the Manila ceiling if equilibrium is to be established through the market by private traders and speculators. Inter-market price ceiling differentials should not exceed transport costs. Deficit regions are an example where ceiling prices might exceed that in Manila but within transport cost limits.

Small regional differences will appear seasonally reflecting varying harvest patterns. This does not require differences in control prices interregionally. It means that seasonal support and injection periods will tend to differ, a consideration sometimes forgotten by head office administrators who are often caught by surprise when price fluctuates in regional centers.

Varietal standards. Two questions arise relative to rice varieties. Should different floor and ceiling prices be specified for key varieties or, if only one set of floor and ceiling prices is used, to what variety should it apply? Historical experience has demonstrated that commonly consumed varieties maintain price differentials that change but little over time. Thus, it can be expected that maintenance of floor and ceiling prices for one popular variety will set the relative price pattern of other varieties.

Selection of the standard variety depends on price policy objectives and market considerations. Considering the usual objective of assuring a reasonable price for the poorer consumer, most countries have chosen to support the floor price of an inexpensive common variety of *palay.* This tends to minimize subsidy requirements for stocks purchased at support levels and injected at the ceiling price. In the Philippines, this would mean a floor price for *palay ordinario,* a category which will include different varieties from region to region and over time, especially considering the rapid adoption taking place of new high yielding varieties. The ceiling price, then, must apply to common inexpensive varieties, with a second class milling that permits larger conversion and thus lower price. Some countries in Asia have attempted to support improved qualities as well as the cheaper ones. Given political and social realities in developing countries, such a policy has invariably increased stabilization costs. Government buying depots tend to classify most receipts at the higher price level, but political pressure requires that all stocks be sold at the ceiling price of the common varieties. To support only a higher quality variety leads to the same pitfalls.

The buffer stock. The price policy described above requires a buffer stock carefully spread out around the country to enable expeditious market injections for ceiling price maintenance. Such stocks are replenished by rice imports when floor price support does not warrant palay purchases of the total required for the next season's buffer. Optimally, the size of the buffer stock will vary seasonally, with injections reducing stocks to a minimum prior to harvest and a maximum some months after harvest.

Subsidies to the NGA (National Grain Authority, which procures rice) can prove a heavy drain on Government revenues to the extent ceiling prices are set too low for recovery of storage and financing costs. Since these costs will vary depending on the degree of stability provided, serious consideration will need to be given to this decision. The buffer stock required to maintain a given ceiling price depends on the amount that annual production deviates from trend, with provision for additional stocks to allow for transport constraints and variable stock dispersion requirements. One standard deviation from the production trend approximates 90,000 tons of rice. In other words, with an allowance of a 10 percent increase for stock dispersion, it could be expected that a minimum buffer of about 100,000 rons of rice (3.4 million cavans of palay) would prove adequate to offset below-trend production and support the ceiling price in two-thirds of the years. A buffer of 200,000 tons of rice (6.8 million cavans of palay) would be expected to be adequate 95 percent of the time. This second alternative is the balance of risk against costs frequently chosen in other Asian countries. At mid-1971 prices, this represents an investment in palay of P150 million with holding costs over a normal year of approximately P15 million.

Management of buffer stocks would then anticipate a decline in stocks before harvest one year in twenty to as low as 20,000 tons. Handling of imports and exports would depend on crop reports early in the year. With poor crops and small buffer carry-over, imports need to be planned for arrival by mid-year. When forecasts indicate bumper crops, surplus for export may be predicted soon after harvest. Whether to hold large surpluses or export depends on relative costs. If exports are resorted to soon after an initial harvest, with adverse weather or disease reducing a later harvest, sufficient time remains to arrange for imports – which may bring a foreign exchange gain if low quality rice is imported to replace higher quality exported earlier.

Implementation and cost considerations. The above recognizes that the NGA cannot in a normal year cover costs of holding its base buffer stock without some subsidy, although the subsidy involved could be reduced by careful stock management. For example, a theoretical study by Shlomo Reutlinger suggests that budgetary costs might be reduced and social benefits increased by maintaining a smaller domestic buffer stock supplemented by more frequent imports and exports. It also is unlikely that the 10 percent seasonal support spread will be sufficient to cover their costs on domestic palay bought and sold.

The subsidy necessary to cover these costs could be partially eliminated by widening the seasonal price spread through raising the ceiling price. While this would conserve Government revenues and benefit the taxpayer, the rice consumer would tend to suffer through higher prices, with the middlemen sharing in the benefits. It is unlikely that much of any benefit would be passed on to the producer. For each 100,000 tons sold by the Government at a 5 percent higher ceiling price, budget savings would approximate P4 million. The effect on the Consumer Price Index would be an increase of less than one-half of one percent.

Finally, there are details of policy implementation critical to success. As described above, the decisions to buy palay or inject rice are determined by market price alone. During critical seasons, management requires daily price quotations of controlled varieties, more specific than the quotations currently being supplied by the Bureau of Agricultural Economics. Decentralized authority for purchase and injection can reduce time lags in taking action. And, management must anticipate the requirements for dispersion of credit facilities in advance of harvest. For appropriate dispersal of buffer stocks, management must have frequent stock reports. Inter-regional shipments will be required at times. Also, firm arrangements must be made for milling palay so that rice will be available when needed. As there are limits to the time that rice or palay stocks can be held without excessive deterioration, arrangements are required for economically replacing old with new stocks when necessary.

[Reprinted in Rice Economy of The Philippines, by Leon Mears, Meliza Agabin, Teresa Anden and Rosalinda Mauquez, pp. 217-224. Quezon City: University of the Philippines Press, 1974.]

Fertilizer Subsidies

Dana Dalrymple

[Subsidies intended to stimulate the use of fertilizer by farmers are relatively common in developing countries, and appear to be increasing. But they can become very costly, especially since the 1974 rise in fertilizer prices; they present administrative problems; and their effectiveness in producing the desired result may be questioned. The available evidence on these matters is summarized.]

The major purpose of subsidies has been to encourage farmers to use fertilizer and thereby expand agricultural production. Since chemical fertilizer is new to many of the farmers in the developing world, a subsidy might be aimed at the innovators and early adopters by lowering its cost. There may be a greater economic need to use a subsidy in the less developed countries (LDC s) than in developed countries because LDC fertilizer prices are often quite a bit higher while product prices may be lower. The recent sharp rise in world market fertilizer prices may lead to a second and relatively new reason for using subsidies: to help maintain existing fertilizer use in cases where product prices have not increased correspondingly. There has been some concern that the higher fertilizer prices will mean a reduction in demand for fertilizer and lower use on key crops.

Other reasons for subsidies are more mixed. It has been suggested, on the assumption that fertilizer production exhibits economies of scale, that subsidies may help expand the total domestic market for fertilizers and make the establishment of fertilizer manufacturing and distribution facilities economical. In

Dr. Dalrymple is an agricultural economist
in the U. S. Department of Agriculture and
he U. S. Agency for International Development.

other cases fertilizer subsidies may be just part of a package to increase food production: in Korea and Bangladesh, for example, fertilizer is part of a program of input subsidies which also includes other farm chemicals, credit, and seeds. In virtually all of these instances, the unstated assumption is that the subsidy is a temporary measure and that it would eventually be withdrawn.

Direct subsidies involve a government payment to some group in the fertilizer production and marketing chain. The major groups are manufacturers, importers, transport firms, distributors (including cooperatives), and farmers. The latter two groups appear to be the most prevalent targets for subsidy (see Table 1).

Table 1. POINTS OF APPLICATION OF FERTILIZER SUBSIDIES
(numbers of cases)

Surveys and Dates:	OECD (1968)	FAO (1974)	FAO/FIAC (1975)
Type of Recipient			
Fertilizer manufacturers	1	6	10
Importers	1	1	4
Internal transporters	3	3	6
Distributors (inc. coops)	3	5	14
Farmers	9	22	7
Unidentified	0	0	11
Total cases*	17	37	52
Number of countries*	17	35	43

*There are more cases than countries because some countries subsidize more than one type of recipient.

Indirect Subsidies. Many of the indirect forms of government assistance may be difficult to classify as subsidies. Others are more obvious. One of the more common is a fertilizer transport subsidy, which can take the form of a subsidy on costs to remote areas. In some cases, credit has been available at concessional terms (in the case of Brazil in the 1960s the interest rates on fertilizer loans varied from 0 to 7% while the rate of inflation went as high as 30%). In Argentina, a double tax writeoff has been allowed farmers on their fertilizer costs; other forms of tax concessions have been used in Chile. In the 1950s Brazil used a package involving a favorable exchange rate for fertilizer imports, tariff exemptions, state and federal tax exemptions, and highly preferential rail freight rates and port fees.

But perhaps the most important form of indirect help, which many might not put in the subsidy category, is the set of fertilization services which can be provided by the government extension service.

Frequency and Size of Direct Subsidies

Direct subsidies are fairly common among the LDCs and have been increasing since 1968. They have been most prevalent in Africa, followed by Asia. FAO and other data for the late 1960s and for early 1970s provide the following breakdown:

Region	Number of Countries	Country
Africa	20	Cameroon, Botswana, Dahomey Ethiopia, Gambia, Ghana, Ivory Coast, Kenya, Lesotho, Libya, Madagascar, Malawi, Mali, Nigeria, Senegal, Sierra Leone, Tunisia, Uganda, Upper Volta, Zambia.
Asia	12	Afghanistan, Bangladesh, India, Indonesia, Iran, Khmer Rep., South Korea, Nepal, Pakistan, Philippines, South Vietnam, Sri Lanka.
Latin America	3	Chile, Jamaica, Uruguay
Total	35	

A more recent FAO tabulation, noted above, suggests that in 1974 more than 43 developing countries had fertilizer subsidy programs. In view of the fertilizer price rise, the list may have lengthened still more in 1975 (Tanzania, for one, was added).

The size of the subsidies varies enormously. Most subsidies fall into the range of 10 to 50% of the farm gate price. It is difficult to make ready and precise comparisons because the subsidies apply at different points and vary by individual types of fertilizer. Some fertilizers are only subsidized if their price rises over a certain base figure. One summarization, based on fairly well standardized and comprehensive FAO tabulations, is available for 28 countries (Table 2). In some countries (Cameroon, Libya, Sri Lanka, and Uganda) the percentage is a constant amount, while in others the proportion varies by type of fertilizer — in some cases rather widely (in Mali the range was from a low of 13.9% to a high of 35.7%, and in Pakistan the range was from 13.6% to 54.5%).

Table 2. RATE OF FERTILIZER SUBSIDY IN THE DEVELOPING COUNTRIES
1968/69 - 1971/72

(Percent of Unsubsidized Retail Price)

	Nitrogenous			Phosphate		Potash	
	Ammonium Sulphate	Ammonium Nitrate	Urea	Single S.P.	Triple S.P.	Potassium Sulfate	Muriate of Potash
Bangladesh	50.0		56.3		55.1		64.5
Botswana				28.7			
Cameroon 1/	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Chile	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Gambia				23.8			
Ghana	37.4			38.4		35.6	28.0
India 2/ 25-50%							
Ivory Coast 3/	33.0	33.0	33.0	33.0	33.0	33.0	33.0
Kenya				23.6			
Khmer	34.0		34.0			34.0	34.0
Lesotho	11.0		11.8	23.7			
Libya	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Madagascar	0.6		5.6				24.8
Mali	35.7		14.9	20.0	13.9		30.2
Nigeria 4/							
Pakistan	54.4	23.2	29.5	56.2	31.0	31.0	13.6
Senegal	47.8		47.6		45.6	27.4	
Sierra Leone	29.8			39.9			
Sri Lanka	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Tunisia	18.2	17.9	20.0				
Uganda	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Uruguay	19.7		81.4	35.3			
Zambia	33.6	33.9	54.6	29.3	28.2	41.4	51.4

Notes:
1/ 10% on all fertilizers used for cotton and coffee.
2/ 25 to 50% on all fertilizers depending on the region.
3/ 33% for cocoa, coffee and rice crops.
4/ About 50% of the state store price on all fertilizers.

Source:
"Note on Fertilizer Subsidies", FAO, 1974, Table 1.

Problems in Subsidy Programs

Management problems. Given a subsidy program, the administrators are apt to face at least two major problems: reaching the intended recipient, and establishing the appropriate subsidy level. The establishment of a subsidy does not automatically mean that it will benefit the group for whom it was intended. Since the subsidy can represent a sizeable source of income many people would like to profit from it, and the benefits to the intended recipient may be substantially reduced. Two striking examples recently occurred in Asia. In South Vietnam, subsidized fertilizer was sold through authorized wholesalers and retailers at official prices. However, a South Vietnamese Senate Committee reportedly found that up to 70% of the fertilizer got into outside hands at one time, and was hoarded to force the price up. Farmers were often forced to pay double or more the subsidized official price. Merchants have reportedly been major beneficiaries of the subsidy program in Bangladesh intended for farmers. In both cases there are stories of smuggling to, respectively, North Vietnam and India.

Even if the fertilizer subsidy does reach the farmer, there is the problem, common to many government programs in agriculture around the world, that some farmers may benefit more than others. In Bangladesh, for instance, there is concern that it is the more economically and politically influential farmers who reap the most benefit from the subsidies. It has been suggested, therefore, that the removal of the subsidies would "neither dampen fertilizer demand significantly nor cause undue hardship to the poorer farmers." Whether such a statement would be true of other countries is unclear; there may be some where subsidies are very important to poorer farmers.

Another major management problem is the establishment of the proper subsidy level. If the subsidy is too low, it may not accomplish its intended purpose of encouraging farmers to take up or maintain fertilizer use. If the subsidy is too high it may lead to wasteful resource allocation. In either case, fertilizer use may be more profitable on some crops than others — and these may not be the ones for which it was intended. By definition, a subsidy means that the official price of fertilizer is less than it would be otherwise. This differential is apt to lead to the establishment of a black market. The black market, in turn, may thwart the original purpose of the subsidy.

Just how the subsidy level is actually established in most LDCs is, at this point, a matter of some mystery. It would appear, however, that in at least some countries there is an effort to strike a balance between official fertilizer and product prices. Indonesia and South Vietnam have for several years adjusted one or both prices to keep the fertilizer-rice price ratio in a certain range; in Vietnam the subsidy was designed to maintain a 2 to 1 ratio between the price paid by the farmers for a kilo of fertilizer and the price received by farmers for a kilo of paddy rice. In other cases, as fertilizer prices have shot up, the subsidy level may have been set at a level which would maintain an earlier level of farmer purchasing power.

In some cases the subsidy has been restricted to certain crops, or a differential pricing system has been established. In Sri Lanka, for instance, the subsidy was restricted to rice, tea and coconut farmers; but other farmers reportedly repurchased the subsidized fertilizer from these farmers at a price below the unsubsidized rate but still at a high enough price to provide a substantial profit to the rice and coconut growers. Hence "it is believed that a substantial proportion of the fertilizer supplied at subsidized rates to rice growers is not finally applied on rice land." In the Philippines, the fertilizer price for export crops has been roughly twice as high as for the subsidized price for rice. Enforcement is attempted by making fertilizer intended for rice available through a series of procurement vouchers. There are several reports of fertilizer being black-marketed and moved from one crop to another.

All of this may not be entirely undesirable in that most of the fertilizer probably eventually reaches those farmers with the greatest effective demand. However, small or poor farmers with potentially high response rates but with limited purchasing power or market access may lose out in the process. Hence, the result of the subsidy program may be quite different from what the governments wanted and/or the public was promised.

Financial problems. Subsidy programs for fertilizer can be very expensive for the modest agricultural budgets of many LDCs. One of the earlier programs, in Chile, was discontinued several times due to lack of funds. In Uruguay from 1961 to 1966, the annual cost of a relatively modest subsidization program was $2.53 million and the government "from time to time" had difficulty in meeting payments. The cost in countries with more extensive subsidy programs is substantial: in South Korea the fertilizer subsidy cost $8.84 million in 1968 and $17 million in 1969; the expected cost of the fertilizer subsidy program in Afghanistan in 1975 is $15.1 million; while in Bangladesh the proposed subsidy in the Five Year Plan totals $50 million.

Where governments have tried to maintain relatively constant prices to the farmer in the face of increasing costs due to the 1974 rise in world prices, the budget burden can be immense. In Sri Lanka the subsidy was discontinued in 1974 because, in part, "the rising cost of the subsidy had become an excessive burden on the GSL budget." Indonesia has found that the cost of its fertilizer program could go from Rp. 2.54 billion ($6.1 million) in 1971 to Rp. 30.0 billion ($71.9 million) in 1973/74, nearly a twelvefold increase. This is viewed as "A burden which would clearly pose very serious financial problems for the country." Had India continued subsidizing fertilizer at previous levels in 1974/75 the cost would have been about $500 million, "an amount which the government can ill afford to bear." The cost of the fertilizer subsidy program in Iran increased from some $22.5 million a year during the 1968/72 period to about $113.5 million a year in 1974.

Clearly, subsidies may have profound financial cost implications for developing nations. And while the precise cost of subsidies is not predictable, neither are the benefits. There does not seem to be a great deal of evidence available to demonstrate the effectiveness of these vast expenditures in stimulating fertilizer use. This absence has been noted in a least several nations: Brazil, Jamaica, Kenya, and Tunisia. This is not to say that subsidies have been ineffective, only that remarkably little evidence seems to be available considering the substantial funds which have been involved. FAO has begun some studies in this area.

Withdrawing or reducing subsidies. Even if subsidies are establishes to encourage initial adoption, there is the problem, previously noted, of reducing or withdrawing the subsidy when the initial purpose is served. This may be particularly difficult with the recent fertilizer price hikes. Bangladesh provides a recent example of the difficulties in lowering a subsidy. As noted earlier, a substantial subsidy was set on fertilizer which turned out to be very expensive, ineffective, and possibly counter-productive. Accordingly, the government began to eliminate the subsidies on a phased basis over a five year period. While the phase-out may have been criticized by some as being too slow, it turned out to be too fast for various vested interests (including large farmers) and consequently ran into stiff political opposition in Parliament in June 1973. Consequently the reduction is being "delayed somewhat."

It may be naive to think that one can get around such problems very easily, but perhaps they would be ameliorated somewhat if their temporary nature were made known at the outset and a gradual phase-out schedule adopted and publicized. For instance, a subsidy for fertilizer on coffee in the Cameroon was scheduled to be phased out from 75% to zero over four years.

Fertilizer Economics

Relatively little seems to be known with certainty of fertilizer economics at the farm level in the LDCs. Yet such information is of vital importance in designing and operating an effective and efficient subsidy program. We will briefly review some of the fragments of information which have been found concerning fertilizer prices, demand, and uses.

Profitability of fertilizer. There are great differences among countries in the prices paid for fertilizer, in the prices received for crops on which it may be used, and consequently in the relations between these prices which determine its profitability to farmers.

In the Indicative World Plan, FAO calculated some benefit-cost ratios which indicate the value of additional output resulting from fertilizer use divided by the cost of fertilizer; the higher the ratio, the more favorable the price conditions for fertilizer use. Generalized ratios were estimated for three regions in 1962 and then projected to 1975 and 1985.

Region	1962	Projected 1975	Projected 1985
South America	2.9	1.9	1.7
Africa (S. of Sahara)	4.4	3.3	3.7
Asia & Far East	4.7	4.5	4.5

The ratios appeared most favorable in Asia and the Far East and least favorable in South America. FAO stated: "Widespread experience suggests that benefit/cost ratios for fertilizers below 2.0 or 2.5 are usually insufficient to create a strong impetus for rapid increases in use." Latin America was projected to fall below these levels. [Note: considerable data on price ratios in particular countries were omitted from this excerpt.]

In view of the current fertilizer price situation, it would be important to know how these ratios have changed; the prices of farm products, of course, have also been changing. FAO has recently compiled some benefit-cost ratios for before and after the recent fertilizer price increases (although the precise dates varied, they were generally considered to be 1973 and 1974 respectively). Of 12 cases, from 10 countries, the ratio declined in 9 and increased in 2; in one case the result depended on whether farmers were able to get fertilizer at government controlled prices. When the data were further broken down by individual crops, out of 54 entries the ratio declined in 41, remained the same in one, and rose in 12. Still, the number of crop cases for which the ratio dropped below 2.0 increased only from 7 to 17; of the latter, 10 were in countries where free market prices existed and 7 where government controlled prices were the rule. Thus for most crops in most areas, fertilizer use continued to be profitable in terms of the FAO guidelines.

These, however, are only a partial measure. They may, in fact, not be highly correlated with profitability of fertilizer use. Data compiled by the International Potash Institute for six countries in 1972 and 1974 indicate that while the ratio declined in five countries, net returns remained the same or even increased. Similarly, FAO data show that even in some areas where ratios have declined moderately, such as in Java, net returns actually increased. Thus, it is probably true, as OECD stated in 1968: "no general ratio between cost and return can be laid down as being necessary to promote fertilizer use in the developing countries as a whole." A number of other factors are involved.

Price elasticity of demand. As might be expected, the farm demand for fertilizer is inelastic in the short run and elastic in the longer run. On the basis of data from a number of studies summarized by Timmer in 1974, one could anticipate that: the immediate impact of a relative price reduction of 10% will be increased fertilizer consumption of anywhere from 5 to 10%; and in the longer run, if the same relative prices are maintained, the increase could be 2 to 3 times greater. Timmer is quick to add that in the longer run the same relative prices are not likely to be maintained.

The short and long term relationships noted here are in part based on the farmers' likely position on an S-shaped physical product curve for output responses to increasing use of fertilizer per acre: a little fertilizer produces small responses; increased fertilization brings a larger response; but above a certain level of fertilizer application the additional output tapers down. In areas of long-standing fertilizer use, farmers may have reached the upper level of the product curve where the marginal product declines. In areas where fertilizer use is more recent, farmers may be on the steeper part of the product curve. Thus, the newer adopters are more apt to get a larger response for a given input of fertilizer than the older adopters, and are therefore less sensitive to price fluctuations.

These figures, based on aggregate price responses of all farmers, do not clearly identify the responses of the small minority of new adopters at any given time. It is these farmers to whom subsidies should be directed; and their price responses might be reasonably elastic if they were found at the lowest portion of the marginal product curve. If the prospective adopters are generally poor farmers, price differences might be quite important to them. All this is difficult to measure with the price response data available. But it seems likely that high prices for fertilizer will, as Timmer put it, "hit the poor farmers and nations with high physical response rates relatively harder" than the wealthier farmers or nations.

Non-price factors influencing demand. Aside from the income level of the farmer, other general constraints are imposed by his related ability to carry, and his attitude toward, risk. Chemical fertilizers represent an additional expense in the production process. Should the rains not come, irrigation water be short, or some other natural calamity befall the farmer, he might not recover his investment. A related factor is the type of tenancy arrangement involved. For example, when a typical tenancy arrangement forces the farmer to pay for all inputs and deliver half the crop to the landlord, the tenant who uses fertilizer loses half the return on his investment. There is also a problem of insecurity of tenure which affects the willingness to take risks.

The farmer's ability to buy fertilizer in the first place may be limited by several factors. One is simply that fertilizer is often not available at the right time and place and in the right form. Distribution channels may not be adequate. In some countries only one nutrient is provided, whereas a blend of nutrients is needed. The availability of credit, or its availability at a reasonable interest rate, is a commonly noted restraint for smaller farmers who do not normally have cash to buy fertilizer during the growing season. Another problem is lack of knowledge: many farmers simply do not have enough information about the value of fertilizer or about how to use it profitably. The availability of irrigation water may also be a significant restraint on fertilizer use, since it affects fertilizer responses. Where non-price factors of these kinds are important, they will greatly limit the numbers of farmers who are likely to adopt fertilizer use as the result of a low subsidized price.

One of the major factors influencing the use of fertilizer is the effectiveness with which it is utilized by particular plants. The fertilizer-responsive wheat and rice varieties that have constituted the backbone of the "Green Revolution" are ample proof of the value of such innovations. They raise the response curve for fertilizer; a given quantity of fertilizer will generally lead to greater levels of crop production with the high-yielding varieties than with traditional varieties. The gap widens at higher levels of application. Because of the presently low levels of use on food crops in LDCs a considerable technical potential exists. Further improvements in plant types and other technologies are likely to be developed. This prospect could be seen as a reason for promoting the habit of using fertilizer by all available means including subsidy — even if the latter is relatively inefficient.

Policy Implications

It is difficult to draw firm policy conclusions about subsidies for fertilizers in developing nations. The types of subsidies and range of conditions are too diverse for easy generalization. Still, some comments are possible. These should be prefaced with the acknowledgement that while I had a fairly open mind about fertilizer subsidies when I began this review, I am now considerably more skeptical about them.

The traditional argument for subsidies in LDCs has been to encourage fertilizer use. There may well be justification for temporary use of subsidies at the very earliest stages of the adoption process —

if it has been determined that a lowered price will provide a significant boost to adoption. This, however, is a significant condition. It is more of a generally accepted nostrum than well-proven fact. Still, it could be true in some cases. And since relatively small numbers of farmers may be involved for only a year or so, the government cost theoretically would not be great. The problem comes if the government doesn't make it clear in advance that the subsidy is temporary and if it doesn't withdraw it quickly enough. As with any subsidy, political pressures can force its continuation long past its period of peak usefulness.

The burden carried by the subsidy process has become immeasurably greater with the recent rises in fertilizer prices. These not only make the introduction process more difficult (to the extent that fertilizer price is important), but can add significantly to the cost of production of the adopting farmer. The short-run problems may be particularly severe for small farmers with limited credit. Thus there may be some need for financial relief at the farm level if fertilizer application and crop output are not to drop off.

The question is, then, whether a fertilizer subsidy is the most efficient and appropriate vehicle. Subsidies can be very expensive in terms of limited LDC budgets and they do not necessarily insure that the fertilizer reaches its intended use. Increased prices of certain crops could help draw the fertilizer into that use. But to do this entirely by supporting the price of the crops could also be expensive. One alternative would be to simply allow increased fertilizer costs to be reflected in increased food prices. This would raise the incentive to apply fertilizer (though it would not guarantee its use) and the "taxing" would be done by the higher consumer prices. Since the lowest income groups in the cities and among farmers not producing food crops would suffer in this process, a food subsidy program might be used to keep nutrition levels from dropping. And additional credit may need to be provided to small farmers lest they be unduly disadvantaged. Such an alternative program may be unrealistic and open to criticism. It is idealized in that few politicians would carry it out in the face of increased complaints about the retail food prices. Also, the program might be considered inflationary. But the sad fact is that unless product prices at the farm level are allowed to rise, there will be little incentive for farmers to increase output.

More general government price subsidies could moderate the increase in crop prices to consumers, but there is always the danger that they might represent an even larger budgetary cost than fertilizer subsidies. This is not to say, however, that there isn't any place where price supports could be useful; a small program might well provide an initial incentive for fertilizer use on certain crops. And if an extensive subsidy program is to be set up, both input and product prices may need to be wrapped up together. Most countries, however, will not be able to afford such a highly subsidized program for very long. Furthermore, there can be a substantial opportunity cost in devoting many resources to subsidy programs. To the extent that policy personnel are engaged in the many complexities of such programs, they may overlook or underfund other important longer-term ways of meeting the fertilizer problem which could lead to a more rationally-based program of fertilizer use on LDC farms in the future.

The problem, as always in the times of crisis, is to escape the present. I see no easy way out. Retail food prices in the LDCs are going to have to be allowed to rise to reflect the higher fertilizer cost. To do otherwise by resorting to extensive subsidies is not going to do the trick very long; it is simply too expensive in budget terms. And it does not lay the economic and technical base for continued production increases in the future.

Thus my own view is that subsidies should be used very cautiously and very selectively. There may be cases where they can help introduce fertilizer or be of needed assistance to small and/or poor farmers. And there may be instances where adjustments in product prices can help direct their use to certain crops. But on the whole I would tend to allow product prices to rise and, where time permits, turn my thinking and limited funding elsewhere — to the better identification of constraints on fertilizer use, to increasing the efficiency of fertilizer distribution and its use by plants. In short I would try to make the best possible utilization of what little fertilizer I had. This would, however, require much more knowledge about the fertilizer situation at the farm level than presently exists in most developing nations.

[Extracted from Evaluating Fertilizer Subsidies in Developing Countries, AID Discussion Paper No. 30. Washington, D. C.: U. S. Agency for International Development, May 1975.]

☆ U. S. GOVERNMENT PRINTING OFFICE : 1976 210-902/3

DEVELOPMENT DIGEST

A quarterly journal of excerpts, summaries, and reprints
of current materials on economic and social development

Gordon Donald, Editor; Donna U. Vogt, Associate Editor;
Renee D. Sumby, Digest Secretary
Prepared by the National Planning Association

for

Agency for International Development, U. S. Department of State

CONTENTS

Volume XIV - Number 3 July 1976

FISHERIES

THREATS TO WORLD FISHERIES 3
Erik P. Eckholm

FISHERY AND RESOURCE MANAGEMENT IN SOUTHEAST ASIA 9
John C. Marr

EFFECTIVE FISHERIES MANAGEMENT WITH REGIONAL DIVERSITIES 26
Francis T. Christy, Jr.

HIDDEN RICHES OF PONDS 38
Tecnica Pesquera

THE OCEAN FOOD AND ENERGY FARM PROJECT 42
Howard A. Wilcox

ENERGY AND AGRICULTURE

ENERGY AND AGRICULTURE; AN EDITORIAL INTRODUCTION 51
Gordon Donald

INTERACTION OF ENERGY AND FOOD PRICES IN DEVELOPING COUNTRIES 54
C. Peter Timmer

ENERGY AND FOOD PRODUCTION 59
Gerald Leach

FUEL FOR AGRICULTURE IN THE THIRD WORLD 69
Arjun Makhijani

FOREIGN INVESTMENT

HOST COUNTRIES AND MULTINATIONAL CORPORATIONS 89
Dale R. Weigel

ECONOMIC NATIONALISM AND THE COPPER INDUSTRY 97
Theodore H. Moran

INTERNATIONAL SUB-CONTRACTING 107
Michael Sharpston

(Unless otherwise indicated currency is expressed in U. S. dollars.)

FISHERIES

CFTRI LIBRARY
MYSORE-2A
12 JUL 1978

BONITO CAUGHT IN A PURSE SEINE, TAIWAN
(PHOTO: OFFICE OF INFORMATION
COMMISSION ON RURAL RECONSTRUCTION, TAIWAN)

Threats to World Fisheries

Erik P. Eckholm

The supply of fish from the ocean is proving highly vulnerable to the rapidly growing capacity for fishing with modern methods; important species are being depleted, yet fishing fleets are expanding. The Peruvian anchovy are a dramatic example of the problem and an illustration of the need for controlled management.]

Until quite recently, the oceans have seemed nearly boundless and endlessly bountiful. Fish have almost always been there more or less for the taking; the size of the catch was dependent only on the fisherman's efforts and skills. Early fishermen were restricted to inland ponds, rivers, and ocean coastlines. First on logs, later on rafts, and finally on boats, their ability to capture fish away from the shorelines grew, but the problem of spoilage still held most fishing vessels to within several hours of population centers. The nineteenth century introduction of ice storage on fishing boats greatly expanded their range, permitting cruises of two to three weeks. By the mid-twentieth century, massive fleets and floating factories able to process and freeze fish right on board could make journeys of many months and, with the aid of helicopters and sonar, could locate and chase down schools of fish almost anywhere.

In the face of improved fishing capacities and a soaring world demand for protein, the oceans have been generous. Between 1950 and 1970 the world fish catch more than tripled; rising from twenty-one million to seventy million metric tons, it reached a new record almost every year. The global catch grew at over 5 percent annually, or more than twice

Mr. Eckholm is with the Worldwatch Institute, Washington, D. C.

as fast as world population, thus significantly augmenting the per capita supply of marine protein. The 1970 world catch averaged out, in live weight, to nearly forty pounds per person.

Fish are an important protein source in many of the world's more populous countries, including Japan, where the average person consumes seventy-one pounds per year; the Philippines, where consumption averages forty-four pounds; and the Soviet Union, where twenty-three pounds is the average. These figures do not include the third of the world catch that is ground into feed and eaten almost entirely by poultry and hogs in Japan, Europe, and the United States. Though the richer countries catch or buy a disproportionate share of the total, fish are virtually the only source of high-quality animal protein for hundreds of millions of the world's poorest people in parts of China, Southeast Asia and elsewhere.

In the mid-seventies, as the era of rapid growth in world fisheries draws to a close, difficult questions are coming to the fore: does human society possess the organizational capacity to preserve this valuable, renewable resource at a high level of productivity? What criteria will be used to divide up the finite ocean harvest when the rich and the poor, the overfed and the malnourished, the powerful and the weak all clamor for more animal protein? The continuing United Nations Law of the Sea Conference marks a transitional period to a new order in the oceans. It remains uncertain whether this will be an order of international cooperation or conflict, of enlightened fisheries exploitation or myopic resource destruction.

How much longer can we expect the world catch to grow? Food and Agriculture Organization scientists, in collaboration with fishery scientists and institutions throughout the world, recently estimated a maximum sustainable world catch of roughly one hundred million metric tons annually. This total includes all species currently sold in the world's fish markets ranging in size from whales to anchovies, and also species not yet exploited commercially but similar in size and appearance to those that are. It assumes that currently underfished regions like the Indian Ocean, the South China Sea, and others will be exploited; that few major stocks will be seriously depleted by overfishing; and that pollution will not destroy marine life over significant areas. Not taken into account is the large-scale utilization of new species low on the food chain, such as the Antarctic krill, a prolific plankton with harvest possibilities of up to fifty million tons should the problems of cost and palatability that now limit its exploitation be overcome. Nor does the estimate include large potential production increases through aquaculture, or inland fish farming.

The possibility of raising the annual global catch from its current seventy million tons to one hundred million tons seems an encouraging conclusion until one runs through the mathematics of growth. If the rate of increase in the world catch of the 1950-70 period could be maintained, the estimated sustainable limit of one hundred million tons would be reached in just eight years. Even if the FAO estimate turns out to be overly pessimistic, and the catch could be doubled to 140 million tons, as some feel is possible, this higher limit would be reached in fourteen years at the 1950-70 growth rate. Every major fishing nation plans to increase its catch, and fleets expand every year; but it remains an open question whether or not the international power to limit fishing efforts can be developed before the potential additions to the catch are used up. An overextended world fleet could rush past the safe limit quickly, severely damaging many species and causing a partial collapse of the oceanic harvest. More likely, the growth in catch may now slow down markedly despite intensified fishing efforts, as the catch of the more easily captured stocks peaks and in some instances declines. In either case, the world will probably not experience a sustained, dramatic increase in the supply of marine protein again.

By the early seventies, serious stresses in the oceanic system had already emerged, raising doubts in some quarters as to whether the catch will ever reach even one hundred million tons. Two decades of continual growth came to an abrupt halt in 1971, when the catch fell to just below the previous year's total of seventy million tons. Then, in both 1972 and 1973, as the important Peruvian anchovy fishery temporarily collapsed, the total world catch dropped still further to under sixty-six million tons. The preliminary estimate for 1974 shows a catch that is back up to the 1970 level, between sixty-nine million and seventy million tons. This sharp dip in the supply of marine protein caught most analysts off guard. The spectacular growth had obscured the less prudent aspects of the process by which that growth was achieved. Hidden beneath the overall growth figures was a continual movement to new species and regions as traditionally preferred species were fished to minimum replacement levels or beyond. A few species have now been virtually wiped out altogether, some have been depleted to a fraction of their potential yield, and many are producing at below their maximum level due to overly intense fishing pressures.

The process by which some fisheries have grown, suffered overexploitation, and then declined is shown in the experience of the Northwestern Atlantic offshore region extending from Rhode Island northward to the southern coast of Greenland. Fished commercially for 350 years, and accounting for 5 percent of the total world catch, this region is in some ways a microcosm of world fisheries and a harbinger of things to come elsewhere. The northwest Atlantic is biologically rich and, as the Soviet and European fleets joined those of Canada and the United States, the area's fish harvest rose steadily from 1.8 million tons in 1954 to a peak of 3.9 million tons in 1968. But though the level of fishing effort has grown with each succeeding year, the total catch has not surpassed 3.5 million tons in any of the five following years for which data are available.

The falling catch of several of the region's most sought-after species is largely due to overfishing and explains the drop in total output. The harvest of cod, the most important single species, reached a high of 1.9 million tons in 1968; by 1973, it had fallen by more than 50 percent. The catch of herring also peaked in 1968, at 0.9 million tons, and was down to 0.5 million tons in 1973. The haddock catch turned the corner earlier, in 1965, when the catch reached 249,000 tons; it had fallen to little more than a tenth of that level by 1973.

The nations fishing in the area have long maintained an International Commission for the Northwest Atlantic Fisheries to collectively oversee the fishery. Though the commission has not been able to reduce fishing efforts to a safe and economically sensible level, its recent strenuous efforts to reduce the pressure on the more gravely threatened species in various sub-regions have, in some cases, helped prevent their total depletion.

Peruvian anchovy. In the southeast Pacific Ocean, off the Peruvian coast, the world's richest fishing ground has just experienced a convulsion that parallels strikingly such terrestrial ecological breakdowns as the recent Sahelian debacle and the American Dust Bowl of the thirties. When a sudden but predictable change in natural conditions occurred that temporarily reduced the system's capacity to support life, the confluence of pressures imperiled both humans and the natural system. This story began in the mid-fifties, when the fishing industry of Peru began the most spectacular expansion in the history of marine fisheries. Ocean conditions off the coast of Peru and northern Chile facilitate an extraordinary concentration of life there. A westwar swing of the Humboldt Current, which flows toward Peru out of the South Pacific, causes a cool, nutrient-rich upswelling from the depths, and, as it reaches sunlight, there is a rich bloom of plants and animals

In the nineteenth and early twentieth centuries, humans capitalized upon this ecosystem by collecting for sale as fertilizer the manure (guano) of sea birds that fed upon the billions of anchovies swarming off the coast. Governmental regulations in reaction to the foreseeable exhaustion of the guano helped dampen this trade, but a new industry, based one step lower on the food chain, emerged. At a time when technological progress permitted more efficient culling of the anchovies, rising incomes and a revolution in the poultry industries of Europe, Japan, and North America were creating a lucrative new market for the fishmeal into which the anchovies are ground. Unfortunately, the anchovies, a vast source of high-quality protein, have been mainly used not to eliminate malnutrition in Latin America, but to help satisfy the growing taste for meat in the industrial countries. In part because of the prolific anchovy, fishmeal has become a frequent protein additive to feeds for broiler chickens that are often now produced in huge, scientifically fed concentrations. As the catch soared in the mid-sixties, Peru became the world's leading fishing nation; its anchovy catch accounted for a fifth of the entire world fish catch in many years. Often, nearly two-thirds of the world's fishmeal exports came from this one country.

High profits generated massive over-investments in fishing vessels and fishmeal-processing plants. Though an excellent system of biological monitoring and fishing regulation was developed, the combination of too many investors with too many boats and the government's hunger for foreign exchange generated strong pressures to continually increase the anchovy harvest. In 1970, an international team of biologists estimated the maximum sustainable yield of the Peruvian anchovy fishery at about 9.5 million metric tons. Political realities had stronger exponents than biological needs, however; the catches in 1967, 1968, 1970, and 1971 all exceeded this estimate, and reached a height of over twelve million tons in 1970.

The anchovy stock had long been known for its instability; an unpredictable warm current, locally known as *el niño*, periodically drives the anchovies deep in search of colder water, and possibly reduces their numbers. In mid-1972, after heavy fishing in the spring, it became apparent that the anchovies had vanished from their usual coastal haunts in the wake of *el niño*. Alarmed by their absence, the Peruvian government halted fishing for the rest of the year. In early 1973, the characteristics of the current remained unusual, and experimental catches indicated the absence of a new brood of anchovies. Fearful that the fishery would be permanently destroyed, the Peruvians closed it for most of that year and part of the spring of 1974. For almost two years, the world's greatest fishery lay virtually idle—two very long years for the fishermen, who were out of work; for the industry owners, some of whom lost fortunes; for the Peruvian government, which lost its chief export; and for consumers everywhere, who found the world protein market disrupted by the sudden shortage of fishmeal.

There has been a tendency in many quarters to ascribe this collapse entirely to nature and *el niño*, but a careful examination of events makes that explanation unsatisfactory. In hindsight, observes John Gulland, a leading FAO fisheries expert, it appears likely that the overfishing of 1970 and 1971 depleted the stock to such a vulnerable condition that, "while recruitment [successful replenishment by a new spawning] could be maintained under average or better environmental conditions, the unfavorable conditions of el niño would cause a recruitment failure that would not have occurred if the adult stock had been larger." After the particularly heavy catch of 1970, an exceptionally small brood was produced in 1971—well before el niño struck. The fishing effort of early 1972 apparently finished off the survivors of both the 1970 and low 1971 spawnings, leaving few adults to replenish the species. By comparison, el niño caused only a brief and modest drop in the anchovy catch in 1965, after annual catches under the recommended level, and did not disrupt the following year's brood.

In 1973, the Peruvian government nationalized the fishmeal industry as part of an effort to reduce its overcapacity. The number of anchovy fishing boats was cut in half. Under the guidance of marine biologists, the government also tightened management of fishing levels. In 1974, as the fishery began to regenerate, a catch of just 3.6 million tons might be permitted. With the new degree of management, biologists hope the fishery will be back to normal by 1977; presumably, fishing will henceforth be held to a sustainable level.

[Extracted from Chapter 9 of Losing Ground, pp. 153-160. New York: W. W. Norton and Co., 1976. Copyright ©, The Worldwatch Institute.]

Fishing boat with net off the coast of Chile (Photo: Interamerican Development Bank)

Fishery and Resource Management in Southeast Asia

John C. Marr

[This article describes the composition of fish stocks of the South China Sea and the fishing activities of countries on its borders. It then discusses the problems of fishery management and the consequences of various policies, concluding that a strong regional organization with authority to make regulations is needed for viable solutions. This presentation of fishery problems in a particular region serves as an introduction to the global discussion of these problems in the next article.]

For the purposes of this review, Southeast Asia includes the South China Sea and the countries bordering it: China and Taiwan to the north; the Philippines in the east; Indonesia in the south; Malaysia - south and west; Thailand, Cambodia and Vietnam (north and south) to the west; along with Singapore, Hong Kong and Brunei. The South China Sea contains a deep basin, the China Sea Basin, as well as extensive continental shelf areas. The main shelf areas are the Mainland Shelf off China, including Taiwan and Hainan islands and Tonkin gulf; and the Sunda Shelf which covers ocean area to the south and west of a line running from South Vietnam across to Brunei, including the Gulf of Thailand. (The definition of the shelf areas as those with water less than 500 m deep is used here because modern trawlers can operate to that depth.) Adjacent to the South China Sea are several smaller seas, which are claimed as internal waters or territorial seas by Indonesia and the Philippines.

Productivity of fisheries is high in the continental shelf areas, although low in the surface waters of the

Mr. Marr is Chairman, Mardela Fisheries Ltd., Honolulu, Hawaii.

deep areas. Enrichment is brought about by vertical mixing in the shelf areas, river discharge, and upwelling. In the South China Sea, vertical mixing over the continental shelf is undoubtedly the main mechanism for nutrient replenishment in the surface layers, followed by river discharge, and upwelling, in that order. Production of fish, crustacea and mollusca is high in the shelf areas. In general, this production is spread over a very large number of relatively short-lived species. Unlike fisheries in the higher latitudes, which are based upon one, or at most, a few long-lived species which tend to accumulate on the fishing grounds, fisheries in the tropics, and especially in the South China Sea, are based upon large numbers of short-lived species. It is, for example, not uncommon to take as many as 200 species in a single trawl haul, a factor which has major implications for fishery development and management.

Important Fisheries

Four countries—China, Indonesia, the Philippines, and Thailand—account for over half of the total production in the South China Sea, but fisheries are of importance to almost all of the South China Sea countries. Only two countries, Brunei and Singapore, have an annual production less than 100,000 metric tons. The fisheries pursued are many and varied, and the fishing gear employed is also varied, including several kinds of trawls, purse seines and other encircling nets, lift nets, gill nets, bagnets, castnets, beach seines, surface longlines, bottom longlines, hook and line, trolling lines, several kinds of stake traps, fish pots, etc.

The major pelagic fisheries, in descending order of importance, are those of the Philippines, Indonesia, Thailand, and Taiwan. (Pelagic fisheries are those based on fishes living near the surface or in midwater, generally not associated with the bottom. Demersal fisheries are those based on species living on or near the bottom.) The important species in the Philippines' pelagic fishery are roundscads, sardines, bigeyed scads, and chub mackerel, all of which are taken in the purse seine-light and bagnet-light fisheries. In Indonesia the major species are Spanish mackerel, fusiliers, and anchovies, taken largely by liftnets and gillnets. The major pelagic species in Thailand are chub mackerel, squid and cuttlefish. Chub mackerel are taken by gillnets, purse seines, and pair and otter trawls; squid and cuttlefish are taken by trawls. In Taiwan the important species are mackerel, bonito, horse mackerel, gray mullet, moonfish, bunas, dolphin, and shark. The gear employed includes purse seines, longlines, and handlines. (Tuna fishing, which presents special global problems, will not be discussed here.) The major demersal fisheries are those of Thailand, China, the Philippines, and Taiwan. These trawl fisheries are based upon large numbers of species; some species groups are widespread, while others are less so. In the southernmost areas there is a tendency for any one species or species group to make up a smaller proportion of the total catch.

National distribution of fisheries. Fishermen from China, Indonesia, the Philippines, Malaysia, Cambodia, and the two Vietnams have remained largely in their national waters. The Southeast Asian countries fishing in more distant waters are Taiwan, Thailand, Hong Kong, and Singapore. The Taiwanese demersal fleet includes baby trawlers (smaller than 50 tons) of which perhaps half the fleet (about 1000 boats) fish in the area off Luzon and Kalimantan where they took about 52,000 metric tons in 1971. The distant-water fishing by Thailand has come about from the pressure induced by overcapitalization of the Gulf of Thailand fishery and the resultant decline in profitability. Starting in 1967 many trawlers moved out of the gulf and operated in the area off South Vietnam. The 1969 catch of these boats was slightly more than 300,000 metric tons, nearly half of the gulf of Thailand catch. Hong Kong trawlers fish from east of Hong Kong to the southwest of Hainan.

The total fishery production of Singapore is about 15,000 metric tons, although total consumption is several times this amount. Currently production fishing is declining in Singapore, owing to more attractive investment opportunities ashore. In 1966, when there was considerable unemployment in Singapore, the government adopted a program to develop a large fish harbor complex at Jurong, which includes unloading facilities, cold stores, auction and market, ice plants, bunkering, processing plant sites, etc. This is used to receive landings from local boats and also import landings for consumption or re-export from foreign boats - chiefly from Thailand, West Malaysia and Indonesia. Vessels from Japan and the USSR have also used Jurong.

The main fishing country from outside the region today is Japan. At present, the Japanese tuna longline fishery produces about 3200 metric tons annually, largely from deep-water areas beyond the shelf. Fishing efforts in northern waters decreased with the escalation of the war in Vietnam and ceased altogether after 1963, but the Japanese government has recently granted permission for pair trawlers to operate in the South China Sea north of 10° north latitude. In Indonesia, a Japan-Indonesia fishery agreement, originally concluded in 1968 and renewed from time to time, permits Japanese vessels to fish within Indonesian waters on a fee-paying basis.

Potential production. Only a few decades ago tropical areas in general were considered to have a very low productivity. In fact, however, the tropics can be very productive, and the South China Sea area is one of the most productive in the world. A number of estimates of potential yields of the South China Sea have been made,

Table 1: Fish Catches of South China Sea Countries, Primarily 1971
(1,000 metric tons)

	South China Sea Only			Total from all sources[a]
	Demersal	Pelagic	Total	
Brunei	0.8	0.6	1.4	2
Cambodia	27.5	7.0	34.5	77
China	410.3	144.4	554.7	6,880
Hong Kong	83.7	28.3	112.0	114
Indonesia	50.0	283.2	333.2	1,245
Laos	-	-	-	20
Malaysia	223.7	138.8	362.5	368
Philippines	208.5	598.3	806.8	1,050
Singapore	11.0	3.3	14.3	15
Taiwan	233.4	217.4	450.8	650
Thailand	984.5	261.7	1,246.2	1,587
Vietnam, North	115.0	100.0	215.0	300
Vietnam, South	309.6	206.4	516.0	587
TOTALS	2,658.0	1,989.4	4,647.4	12,894
Japan		3.2	3.2	9,949

Source: FAO

a. Includes in addition fresh water fish from ponds and rivers, and catches from other ocean areas: primarily the former for China and other mainland countries, the latter for Japan, and both for Indonesia.

the most recent of which project an increase over the 4.6 million tons in 1971 by about 3 million metric tons. An earlier estimate (FAO, 1969) of total potential production in the South China Sea and adjacent seas ranged from 4.9 to 7.2 million metric tons, and other estimates have run over 10 million tons. Historically speaking, estimates of fishery potential tend to be conservative: it may be expected that the potential increase in South China Sea fishery production will be at least 3 million metric tons, most of it in the Sunda Shelf area.

The Problems of Management

In Southeast Asia, the problems of fishery development and management follow a pattern that has become all too familiar throughout the world in the decades after World War II. They include overcapitalization, biological overfishing, fishery management (including allocation or distribution), resource management, and political problems. Overcapitalization, and thus economic waste, are inevitable in a fishery in which there is unlimited entry. This common property characteristic is particularly difficult, if not impossible, to change in the absence of jurisdiction. In brief, the waste is caused by open access and redundant vessels: low returns to fishermen are caused by the time lags between events in the fishery and the time that these are perceived by investors, and between the time a decision is taken to build a boat and the time when the boat enters the fishery. When a fishery first starts, it is usually very profitable. This causes the entry of additional boats, either by new construction or by movement from another fishery. As the number of boats entering the fishery increase, the total catch is divided among more and more boats and individual profits decrease. Eventually the point is reached at which income just covers operating costs; beyond this number of boats there will be a net loss, and presumably the less efficient boats will be forced out of the fishery. This sequence of events will be inevitable unless there is control of the fishery in such a way that the number of vessels entering the fishery is restricted to that level appropriate to the yield of the fishery.

Biological overfishing is not inevitable. If the level of fishing effort at which biological overfishing occurs is substantially greater than the level of effort at which the fishery becomes unprofitable, then biological overfishing most likely will not occur. On the other hand, if the two levels are very close, then biological overfishing most likely will occur. If world demand and the price of fish rise rapidly relative to production costs, then the fishing effort level at which the fishery remains profitable will become increasingly larger, greatly adding to the likelihood of biological overfishing.

Biological overfishing can be of two kinds. First, it frequently, but not always, happens that the relationship (generally referred to as the yield per recruit relationship) between gain in weight of a group of fish—say, members of a single year-class, through growth of its members and loss in weight through death of some of its members—is such that there is a maximum weight of the group at some particular age. If the fishery is so intense that the maximum weight is never reached, then biological overfishing has occurred. Second, there may be a stock and recruitment relationship operating in such a manner that a large spawning stock size produces a large recruitment and a small stock size produces a small recruitment. It is by no means clear that this is generally the case or for how many species. Still, if it is the case, then a high level of fishing effort would reduce the spawning stock size which in turn would reduce the amount of recruitment. It is almost impossible to obtain information on the stock and recruitment relationship; indeed, this is one of the most perplexing problems of fishery biology. Given adequate information, it is possible to work out the yield per recruit relationship; but in situations where one does not have simple and reliable catch and effort data, it is not likely that this kind of information will be available. Furthermore, fisheries may develop so rapidly that, for management purposes, there simply isn't enough time for elaborate analyses or for those requiring relatively long time-series of data.

Fortunately, if catch and effort data are available, it is possible to determine the maximum sustained yield of which a resource is capable. Management of a resource by setting the maximum sustained yield as a total catch quota will conserve the resource; but allowing unlimited entry to the fishery will inevitably lead to economic loss. Losses from overcapitalization can be avoided only by limiting entry according to the potential yield of the resource. Thus, it is the fishing effort rather than the total catch which should be regulated.

Barriers to this kind of management in the Southeast Asian countries include the lack of adequate catch and effort data, of resource information, and of technical staff. Still, most if not all countries in the region have a statistical base and a staff base upon which to build. Indeed, in some countries the technical staff, if not the statistical system, is of a very high order indeed. Perhaps a more important barrier is the political difficulty in implementing needed fishery management decisions. An example, by no means unique, is the trawl fishery in the Gulf of Thailand. The Thai government, through its own survey cruises had good information, on a current basis, about what was happening in this fishery and had been forewarned as to the consequences of allowing the fishery to develop in an uncontrolled manner. Nevertheless, it was apparently easier politically to suffer the consequences of following a policy of unlimited entry with no catch quota than it was to restrict entry into the fishery at an appropriate level.

The most difficult problem connected with limiting entry into a fishery is that of allocation: who is to receive the benefits from the fishery? Some of the criteria frequently advanced include proximity, manageability, historic rights, need, capacity to exploit, and common heritage. While there are arguments in support of each of these, there are frequently equally valid arguments against them. In any case, even if these or other criteria could be accepted in principle, they would be difficult to apply in practice. For example, what constitutes proximity?

Let us assume that fishery jurisdictions are extended to 200 miles. The southern Sunda Shelf fishery resources would then lie primarily in the extended zones of Indonesia and Malaysia. It would be a fairly straightforward task to determine the maximum sustained yield of, say, the demersal resources of the area (ignoring for the moment the movement of resources between two or more zones). It would also be a fairly straightforward task to determine the amount of fishing effort necessary to take the maximum sustained yield or, better, the amount of fishing effort necessary to maximize the economic yield. Then, within the Indonesian zone, it would be fairly simple for Indonesia to allocate the fishing rights to its own nationals because the government already has the authority to make such allocations, and there is presently very little fishing by Indonesia within the zone. But Taiwan, Thailand, and Singapore have been fishing in the area, some for many years and with a substantial annual catch. Such countries could press claims for the right to continue fishing in the area on the basis of their records—historic rights—and because of Indonesia's inability to immediately harvest the resources at the maximum level. Other countries, such as Korea and Japan, might then press their claims on the basis of the latter reason, and also upon their need for additional sources of food. While Indonesia, in this illustration, might find it easy to resist some of these newer claims, the claims of historic right might well prove difficult to resist. If such claims were recognized, they could be limited to some specified period of years, after which the right would no longer exist. A country in the position of recognizing such a right—Indonesia—would also wish to capture some benefit for itself, particularly if it were not itself able to exploit the resource immediately. Thus, the recognition of historic rights might be made dependent upon the payment of a fee or rent for the exercise of the historic right. Or the recognition of foreign rights might be conditional on the formation of a cooperative venture with nationals of the country of jurisdiction.

Finally, there are political problems in the region which impinge on fisheries: it is not reasonable at this time to expect China and Taiwan to sit down together at the conference table in order to negotiate the management of fishery resources. In other cases there are conflicting territorial claims, as well as problems of political compatibility which are not wholly predictable.

Some Aspects of Management in South China Sea Conditions

Mention has been made of the tremendous proliferation of fish species, some 2500, in Southeast Asia. This multiplicity of species has several implications with respect to Southeast Asian resource management and fishery management. First, there are almost no single-species fisheries in this area, whereas they are common in the high latitudes. Second, the ratio of fishery scientists to the number of species is so unfavorable that the kind of information commonly believed necessary for management simply will not become available in the future except for a handful of species; and third, because of this, some new approaches to management must be found.

Although it is true that some of the pelagic fisheries, such as the Rastrelliger or chub mackerel fishery in the Gulf of Thailand, may take only one or a few species, the demersal fisheries are universally multispecies fisheries, with individual trawl hauls containing as many as two hundred species not uncommon. Many species are taken, but usually not many individuals of a single species are taken in any one catch. For example, in Thailand shrimp generally occur as a by-catch in the trawl fishery for fish, and their relatively high value makes it profitable to sort them out of the mixed catch. Generally speaking, then, processing and marketing arrangements which require large volumes of single species will not develop in the South China sea demersal fisheries. About one-third of the demersal catch consists of "trash fish," that is, fish for which there is not a ready market for direct human consumption, either because the species are not in demand or because the fish taken are small juveniles of otherwise acceptable species. In Thailand, and to a lesser extent elsewhere, this trash component of the catch is not discarded dead at sea, but is used for duck food, catfish food, or for the production of fish meal, so that it is not wasted. If there were no market for it, the mesh size of the trawls might be increased, allowing the small fish (and, it should be noted, the shrimp as well) to escape relatively unharmed. From a resource management viewpoint this might be preferable, although these alternatives have not been compared critically to my knowledge.

Because of such ecological complexity and the disparity between the number of scientists and the number of fish species, as well as the urgency of management problems, the development of new management technologies and new ways of conceiving and handling fishery management problems is essential. Although it is obvious that the needed new technology cannot now be specified in detail, some of its characteristics can be. Foremost among these is the need—especially for the trawl fisheries—for methodology which will enable treatment as a single unit of the entire ecological assemblage upon which the fishery is based. Indeed, a major step in this direction has already been made by Gulland (1972), Isarankura (1971), and others. Another aspect is the possibility of influencing the species mix in the fishery in a desired way through appropriate regulation of fishing intensity. Tiews et al. (1967) have reported the change in relative abundance of the components of the trawl catch in the Gulf of Thailand over only a three-year period. Subsequently, cephalopods have increased greatly in the catch relative to fish. Eggleston has remarked on the change in relative abundance over time in the Hong Kong trawl fishery, with deep-bodied species becoming less abundant relative to long-bodied species. Thus, it may be possible to bias the species mix in favor of those species in greatest demand (that is, of highest value) by fixing fishing intensity at the appropriate level.

An additional point is the almost complete lack of information on the distribution or range of the self-perpetuating population units. For example, suppose that a species is known to occur from Taiwan to Indonesia: is it a migrating species—one in which individual fish move between the two areas? Then, obviously, what happens in the fishery in Taiwan will have an effect on the fishery in Indonesia, and vice versa, and any management scheme must take this into account. Or, is it a sedentary species—one living in separate areas with virtually no movement from one area to another? Then fisheries in Indonesia and Taiwan will have no effect on each other. It is known that many species in the area are wide-ranging. In fact, of the 324 commercially important species listed by the FAO, only three are restricted to one country and only nine restricted to two countries, so that 312, or 96 percent, are found in three or more countries. There is the possibility of more or less local, self-perpetuating population units within widely distributed species. But information on this possibility is simply not available within the medium-term future for more than a small number of species at best. Lacking evidence to the contrary, it must be assumed that a substantial proportion of the resources should be regarded as multinational rather than strictly national, and the management regime will need to be international.

The Alternatives

Alternatives for dealing with the management of fisheries in the South China Sea fall under three headings: (1) continuation of the *status quo*, (2) the extension of fishery jurisdiction, and (3) the provision of management mechanisms. The last might include bilateral arrangements, which in the South China Sea area would appear to be the joint venture or cooperative venture; multilateral arrangements; and possibly, although not very likely, regulation by existing multinational organizations.

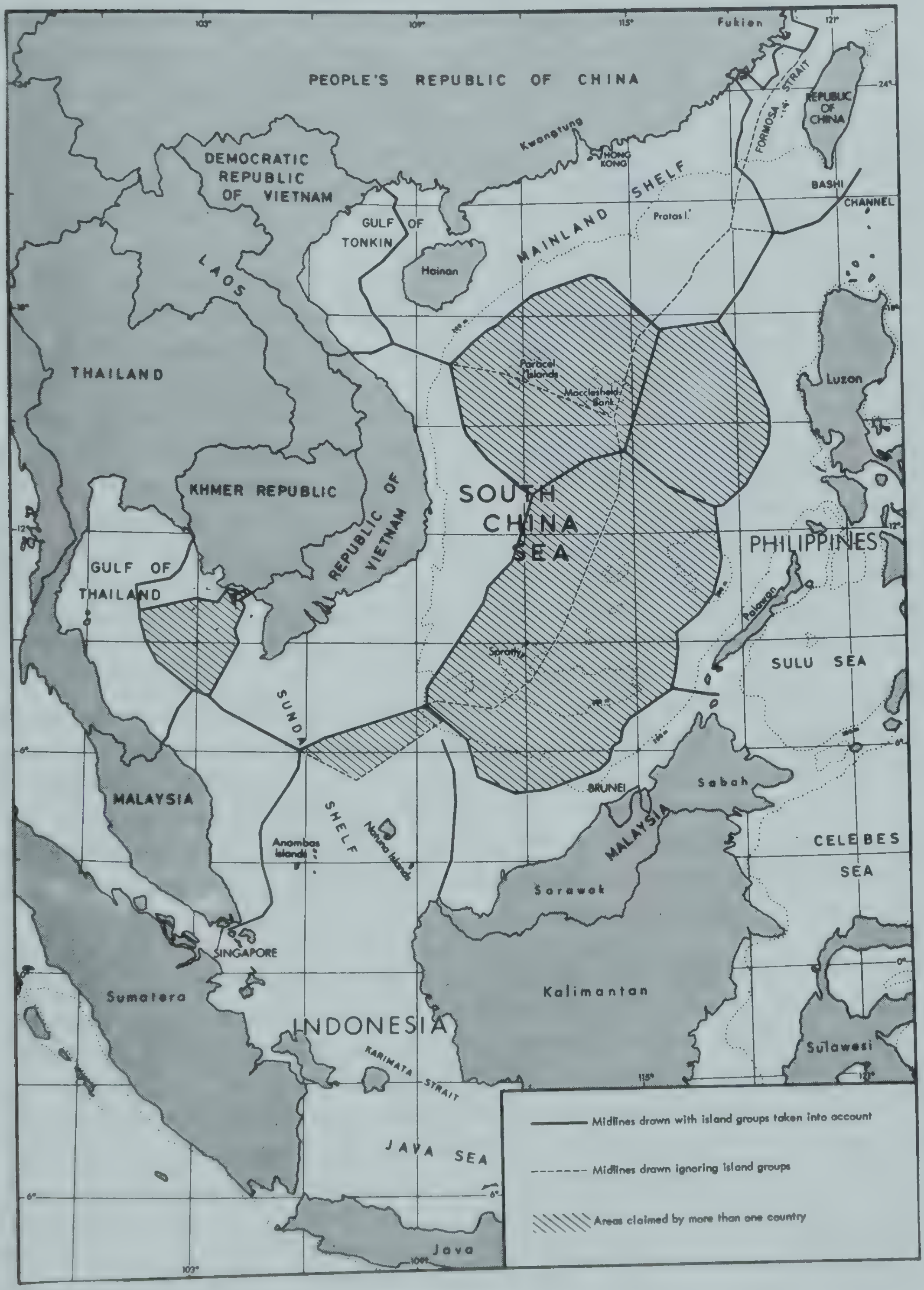
Continuation of the *status quo* will mean an extension of overcapitalization of the fisheries, biological overfishing of the resources, and increasing confrontation between countries. Overcapitalization will continue to occur, not only within individual countries but also when two or more countries exploit a single fishery resource as though each were the only one involved. This may be expected to occur with respect to the demersal fisheries on the southern Sunda Shelf and the pelagic fisheries of the South China Sea. As demand for fishery products continues to grow, biological overfishing may be expected to follow overcapitalization. As these conditions become more marked, there will be increasing confrontation between countries; and the intrusion of the fishing boats of one country into the territorial waters or exclusive zone of another, already happening in the region, will occur with increasing frequency. Undoubtedly, when these conditions become so serious that they can no longer be ignored, countries will attempt to reconcile the differences and to impose some sort of management regime. However, there is a wealth of experience elsewhere in the world which demonstrates conclusively that it is very difficult to reverse such situations and that, in any case, it is much easier, as well as much more efficient, to manage fisheries and resources prior to the onset of overcapitalization and overfishing.

Extension of Fishery Jurisdiction. The present zones of claimed fishery jurisdiction by Southeast Asian countries are mostly rather narrow—leaving aside the special situation of the archipelago states of Indonesia and the Philippines. It seems inevitable that these zones will be extended in the near future, that not only will the shelf areas in the north, west and south be brought under the jurisdiction of individual countries, but that the extension will probably be 200 miles (or to the midlines, when the distance between countries is less than 400 miles), so that all of the South China Sea will fall under various national jurisdictions.

The boundaries of extended jurisdiction zones—if these were extended to 200 miles, that is, to the midlines in the South China Sea—are shown in Figure 1. Ignoring the outlying island groups, the broken line indicates the midline. The solid lines indicate midlines drawn when these island groups are taken into account. Islands or island groups claimed by more than one country give rise to conflicts affecting the shaded areas on the map. Hence, the solid lines have no connotation as to how these conflicting claims will be resolved. The magnitude of the areas involved, and the fact that oil deposits are or may be involved, suggest that these conflicting claims will be difficult to resolve.

It is to be expected that the distant-water fishing countries in the South China Sea area will oppose the extension of fishery jurisdiction should such jurisdiction carry exclusive rights to fishery resources. Thus, the important question about the extensions of fishery jurisdiction in the South China Sea is, as elsewhere, what is the content of such jurisdiction? For varying reasons it might be expected that China, Indonesia, Cambodia, Malaysia, the Philippines, and North and South Vietnam would favor exclusive jurisdiction for the coastal states. It may also be expected that Hong Kong, Singapore, Taiwan, Thailand, and, of course, distant-water countries such as Japan would strongly oppose exclusive jurisdiction, although they might not oppose it if the extension is not exclusive but is constrained by certain international rules. That is, these countries might be expected to favor the "full-utilization" proposal, which provides that a country not fully utilizing its own fishery resources must permit fishing by the nationals of other countries.

Figure 1. Boundaries of jurisdictional zones extended to the midlines in the South China Sea


PEOPLE'S REPUBLIC OF CHINA
Fukien
REPUBLIC OF CHINA
FORMOSA STRAIT
Kwangtung
HONG KONG
BASHI CHANNEL
Protas I.
MAINLAND SHELF
DEMOCRATIC REPUBLIC OF VIETNAM
GULF OF TONKIN
Hainan
LAOS
THAILAND
Paracel Islands
Macclesfield Bank
Luzon
KHMER REPUBLIC
REPUBLIC OF VIETNAM
SOUTH CHINA SEA
PHILIPPINES
GULF OF THAILAND
Palawan
Spratly
SULU SEA
SUNDA SHELF
MALAYSIA
BRUNEI
Sabah
CELEBES SEA
Anambas Islands
Natuna Islands
Sarawak
SINGAPORE
Sumatera
Kalimantan
INDONESIA
KARIMATA STRAIT
Sulawesi
JAVA SEA
Java
103°
109°
115°
121°
24°
18°
12°
6°
0°
Midlines drawn with island groups taken into account
Midlines drawn ignoring island groups
Areas claimed by more than one country

The extension of jurisdiction may facilitate rational controls in those cases where a fishery resource previously used by two or more countries becomes, by virtue of the extension, subject to the jurisdiction of only one country. But since the fish will move freely between jurisdictional zones, in many cases the extension of jurisdiction alone will not solve the international problems of overcapitalization and biological overfishing. Clearly, while extension of fishery jurisdiction zones may not only be inevitable but useful, there also needs to be provision of management mechanisms at both the national and international levels.

Management Mechanisms. The first requirement for dealing with international fishery management in the South China Sea area is an internal management mechanism in each country bordering the sea. The exact nature of such mechanisms—presumably residing in a department of fisheries or its equivalent—will vary from country to country. The mechanism should include the responsibility and authority for development and management according to the country's fishery policy, which should be clearly and specifically defined. Fisheries development and management will involve (1) carrying out appropriate research, including the collection of the basic catch, effort, and biological data; (2) formulating, adopting, and enforcing regulations; and (3) the allocating of resources. This will be costly in terms of personnel and funds and may be difficult in the sense of finding politically acceptable solutions to difficult and complicated problems. However, without effective national mechanisms, it will not be possible to have an effective international mechanism.

Perhaps the simplest form of international mechanism is the bilateral agreement. Such two-country agreements usually deal with a specific fishery resource, but they could also deal with all the resources of a particular area. Under bilateral agreements, the information necessary for management decisions is usually developed by the fishery departments of two countries acting individually or in concert.

Although it is not generally thought of in this connection, the joint venture may be a form of bilateral agreement that is useful in management. In some areas of Indonesia, for example, the effort in the shrimp fishery is controlled through joint venture licenses. Although at the outset the optimum level of fishing effort is not known, it is being approached conservatively by initially restricting the effort by the joint venture company to a reasonably low level. The basic statistics are monitored by the government, and the amount of effort is allowed to increase as appropriate. The joint venture is usually thought of as an agreement between the government of a developing country, which supplies access to the resource, and an economically developed country which supplies technology, capital, and frequently markets. Both sides share in the profits by some agreed-upon formula. But the two partners could also be adjacent developing countries: for example, Thailand has recently shown great interest in the formation of cooperative ventures with Malaysia and other neighboring countries. Thus, cooperative ventures between South China Sea countries may be a useful mechanism to further the interest of both parties within a general framework of management.

Multilateral arrangements, usually simply an extension of bilateral arrangements, are traditionally concerned with a specific fishery resource; they could be concerned with all or many of the resources of a particular area. But even in an area as small as the South China Sea, if each fishery resource management problem were to be taken up on an ad hoc basis, the proliferation of bilateral and multilateral agreements would soon exceed the ability of governments to cope with them. And this can easily be generalized to a worldwide basis; no government could cope with all the agreements needed on an ad hoc basis. Each agreement will customarily take two or three years, or longer, in preliminary preparation and negotiations, depending upon the importance and complexity of the problem. After the agreement is reached, each meeting held thereafter (usually annually) may require a great deal of preparatory work as well as attendant costs such as travel. Those attending the meetings and involved in such preparations within a particular government are the same people, and they have substantial other responsibilities. Since their numbers are small, it is impossible, because of time limitations, for these officials to be involved in more than a few arrangements at any one time. This suggests the need for a single multilateral agreement, which would deal with all of the fisheries management problems of the South China Sea involving two or more countries.

Are there any existing multilateral fishery bodies which might be able to assume this function? At present there are three possibilities. The Indo-Pacific Fisheries Council, formed in 1948, is an FAO commission for a region including, but not limited to, the South China Sea area. It seems unlikely that this council would be acceptable to the South China Sea countries as the mechanism for fisheries for at least three reasons. (1) There are eighteen member countries on the council, some of which are far removed from the South China Sea, and it is most doubtful that the countries of the region would wish to turn over their management problems to such a large and diverse body. (2) Over the years FAO has not been responsive to most of the requests addressed by the council to FAO. The reason given for this by FAO is that it operates on a finite budget and it has not been possible to accommodate these requests. (3) The council secretariat, which presumably would carry out management activities on behalf of the council, is part of the FAO staff; it is unlikely that the South China Sea countries would wish to vest this responsibility and authority with individuals over whom they had at best only tenuous control. Similar reasons would apply to the UNDP/FAO South China Sea Fisheries Development and Coordinating Programme which is, in addition, likely to have too short a life-span to deal effectively with management needs.

The other existing multilateral body is the Southeast Asian Fisheries Development Center (SEAFDEC). This organization has a fishermen's training center in Thailand and a research training center in Singapore, while an aquaculture training center has recently been established in the Philippines. Its members include Japan, Malaysia, the Philippines, Singapore, South Vietnam, and Thailand. While SEAFDEC probably could not undertake the fisheries management responsibilities for the South China sea countries under its present membership, the possibility of it doing so in the future should not be overlooked. Of the three bodies mentioned, SEAFDEC at least comes closest to the requirement of having a responsive staff.

There are, in fact, no existing multilateral bodies which would be acceptable in their present form or could undertake the fisheries management responsibilities in the South China Sea. There is an urgent need for such a body, a South China Sea Commission if you will, to undertake such responsibilities. Formation of such a commission would involve consideration of membership, functions, staff, cost and funding, location, and organization work. Its membership should include all twelve South China Sea countries and political entities. It may be unrealistic to expect all of these countries to work together at this time, but full membership must be achieved if international management is to be effective. If there are distant-water countries, such as Japan, fishing in the area, then they should be included; but it might be desirable for such distant-water countries to attend the South China Sea Commission meetings as observers rather than as members.

The functions of the South China Sea Commission might include research and the formulation and adoption of regulations, their enforcement, and allocation. Research should be directed only toward topics relevant to management. The formulation of regulations would come about by interaction among the commission and technicians on the staff of the commission or on the staffs of member countries. Depending upon the organization of the commission and the amount of authority the member countries would be willing to delegate to it, regulations might come into force either upon their adoption by the commission staff or by majority or two-thirds vote of members. This would be the most efficient procedure because it could be reasonably rapid and it would be more difficult for special interest groups within countries to block agreements. If member countries were not willing to delegate that much authority, then, following adoption by the commission, regulations would not come into effect until they had been adopted by the appropriate countries as specified by the commission. Regardless of how regulations come into force, it is almost certain that enforcement of the regulations would be by the member countries and not by the commission itself. This would be much less costly and, perhaps, much more palatable.

The formation of such a South China Sea Commission would need a period of preliminary preparation which would require funds and a sponsor. Support might come from the countries concerned, or possibly from the FAO or the UNDP; sponsorship would require a certain degree of neutrality. Another possible sponsor might be ASEAN (Association of Southeast Asian Nations). ASEAN members do not now include all of the South China Sea countries, but ASEAN has the clear advantage of being a purely regional organization with no outside obligations or entanglement.

The difficulties in resolving all these problems are clearly very great, but the realities of fisheries-resources management in the South China Sea indicate that there must eventually be some kind of regional fishery management. Continuation of the nonmanagement status quo will only lead to continued economic and biological disaster. The countries of the region must be able to act in their own self-interests on the basis of medium- and long-term gains as opposed to short-term gains. Indeed, the need for deferral of short-term gains in favor of medium- and long-term gains is one of the most critical and difficult problems extant in all fields of human endeavor today. As Crutchfield has said, "It must be remembered, however, that the long term is a series of short terms strung together, each of which must be politically acceptable."

[Extracted from Fishery and Resource Management in Southeast Asia, pp. 4-58, RFF/PISFA Paper No. 7, a booklet published by Resources for the Future, Inc., Washington, D. C., 1976.]

Note: This booklet is one of a series, listed below, published by Resources for the Future on the fishing regions of the world. These can be obtained by writing: Resources for the Future, 1755 Massachusetts Avenue, N. W., Washington, D. C. 20036, USA. The following article provides a global overview of the results of this research by the Director of the Project.

Series on Worldwide Fisheries

Francis T. Christy, Alternative Arrangements for Marine Fisheries: An Overview. RFF/PISFA Paper 1, 1973.

James A. Crutchfield and Rowena Larson, West African Marine Fisheries: Alternatives for Management. RFF/PISFA Paper 3, 1974.

Edward Miles, Organizational Arrangements to Facilitate Global Management of Fisheries. RFF/PISFA Paper 4, 1974.

Arlon R. Tussing and Robin Ann Herbert with Jon G. Sutinew, Fisheries of the Indian Ocean: Issues of International Management and the Law of the Sea. RFF/PISFA Paper 5, 1974.

Saul Saila and Virgil Norton, Tuna: Status, Trends, and Alternative Management Arrangements. RFF/PISFA Paper 6, 1974.

John C. Marr, Fishery and Resource Management in Southeast Asia. RFF/PISFA Paper 7, 1976.

LEFT: Purse-seine fishing off Palawan Island in the Philippines (Photo: FAO)

ABOVE: Fish Breeding operation in Java (Photo: United Nations)

LEFT: Raising milkfish in Taiwanese ponds. (Photo: Commission on Rural Reconstruction, Taiwan)

RIGHT: the transfer of tunny fish from truck to ship in Penang, Malyasia (Photo: International Labour Office)

Effective Fisheries Management with Regional Diversities

Francis T. Christy, Jr.

[The search for a uniform international fisheries regime at the United Nations Conference on the Law of the Sea will be impeded by the great diversity of conditions found in the different fishery regions of the world. The disparity among these situations is likely to set limits to the uniformity of general rules and principles that might be acceptable to the many nations participating in the Conference.]

As the delegates to the United Nations Conference on the Law of the Sea meet to consider alternative international regimes for the management and distribution of marine fisheries, they will be faced by the discomforting fact that there is little, if any, uniformity in the major fisheries throughout the world. There is wide disparity in fishery situations with regard to a number of important factors - the characteristics of the stocks, the history of use, the nature of existing arrangements, and the interest and status of both the nearby coastal States and the foreign States whose vessels come from distant waters. This remarkable dissimilarity between regions and kinds of fisheries will significantly constrain the search for uniform principles and general conventions that will be agreeable to a large majority of the 150 nations concerned.

Despite these regional differences, there are certain fundamental characteristics that are common to all fisheries. One of the most important, of course, is the simple fact that fish swim and do not respect man-made boundaries. But not all fish have the same

Dr. Christy is with Resources for the Future, Inc., Washington, D. C.

degree of mobility. Thus, there are four general classes than can be described: (a) where a fish stock falls entirely within the jurisdiction of a single coastal State, (b) where a stock swims within the jurisdiction of two or more neighboring or opposite coastal States, (c) where a stock swims both within the jurisdiction of coastal States and outside on the high seas, and (d) where a stock is found entirely outside national jurisdictions. Obviously, the classes are affected not only by natural conditions - such as the shallowness of the seas or the presence of upwellings - but also upon the boundaries of jurisdiction of coastal States. For example, we in the United States with our long coastlines view the sharing of fish stocks with quite a different perspective than do the fishermen of Ghana or the Ivory Coast, where coastlines are short and sharing of stocks is common.

Another, and related, fundamental characteristic of fisheries is that partial management is virtually tantamount to no management. Unless a stock is subjected to uniform rules wherever it occurs, the stock is likely to be vulnerable to depletion. If State A has no controls over a stock that is also found in State B, there is no incentive for the latter to conserve the stock because it would simply be reducing its own benefits in favor of its neighbor's. Without sufficient controls, the fishery will inevitably attract too many fishermen and vessels, and the costs of labor and capital will be much greater than they should be - that is, the same (or perhaps larger) value of total catch could be produced with fewer fishermen and vessels. But this control of fishing can only be achieved where the State, or some agent acting for two or more States, can exercise a high degree of authority.

The ability to exercise a high degree of authority is impeded by another fundamental characteristic of fisheries - the disparity among the goals for fisheries management. Some States may wish to use fisheries as a source of net economic returns, whereas others may desire greater opportunities for employment, reduction in the imports of protein materials, enhancement of maritime skills, etc. Where States sharing a single stock have different goals, agreement on the distribution of benefits presents considerable difficulties, and the choice of management techniques is complicated.

While these fundamental characteristics pertain to all marine fisheries, the ability to deal with them depends upon a large number of factors including the physical attributes of the stocks, the geographic boundaries of States, and the social, economic, and cultural patterns of the different societies. Some of the management problems that arise are illustrated here in summary description of those found in several fishery regions, and for one type of fish requiring global management.

The North Pacific

Perhaps the most distinguishing characteristic of the North Pacific ocean region (here considered roughly the area north of Japan and Mexico) is the small number of States that have an interest in the fisheries. Until a few years ago, only four States - Japan, the Soviet Union, Canada, and the United States - had vessels operating in this region beyond narrow coastal waters. All four States are highly developed and have long traditions of fishing. A second important characteristic is that, like all other areas of high latitude, there are relatively few species of fish but large populations of each species. This, together with the high natural fertility of the region, has encouraged the development of specialized fleets concentrating primarily on individual species. In addition, the areas of high productivity cover extensive areas of the ocean, particularly in the Bering Sea where the continental shelf extends well beyond 200 miles. Third, the history of use in the region has been so great that most of the valued stocks have been fished to, or beyond, the point of maximum sustainable yields. (One possible exception is pollack, which now makes up about a fourth of the total marine catch of the region.) Even though fishing effort continues to increase, the opportunities for taking larger catches are quite limited.

The first international fishery conservation agreement of modern times - the fur seal treaty - occurred in this region and has been operating for more than 60 years except for a lapse during the Second World War. Since then many other multilateral and bilateral agreements and treaties have been made, and more than fifteen such agreements are now in effect. There are more agreements explicitly dividing up the resources in this region than in any other area of the world. Fur seal yields have been divided by all four States. Divisions of the yields from salmon stocks have been made between Canada and the United States; between Canada, the United States, and Japan; and between Japan and the Soviet Union. A similar array of distributional agreements are also in effect for king crab. This remarkable record of agreements, however, is being threatened by new developments and increased fishing pressures. As world prices for fishery products climb, so does fishing effort. But since the supplies are limited, the result is decreasing shares per unit of effort.

A second pressure - and one more difficult to alleviate - is the entry of new States into the North Pacific. In recent years, vessels from South Korea have started fishing in the region and there are clear indications that vessels of North Korea, Poland, and East

Germany will be entering. These new entries provide major threats to the continued viability of the current arrangements that are based on the assumption of closed access. For example, the "abstention" agreement, under which Japan abstains from taking salmon east of W. 175° longitude, would collapse if the South Koreans were to take significant amounts of salmon within this area. Similarly, sealing on the high seas by any of the new entrants which are not parties to the fur seal convention would make the present arrangement meaningless.

A third problem is that the agreements, even though large in number, are highly specific in nature and do not provide comprehensive coverage of all of the region's needs. Some of the newer fisheries, like those for pollack, saury and squid, remain essentially unregulated, while the other fisheries are the subject of complicated and time-consuming negotiations. There is no single forum that would facilitate coordination among the many separate ad hoc agreements or would allow rapid responses to the newly developing pressures.

In view of the particular conditions that exist in the North Pacific, it is difficult to see how the likely decisions at the Law of the Sea Conference would significantly alleviate the problems of the region. Two of the major participants - Japan and the Soviet Union - are strongly opposed to extended limits. But even if they should agree to this, it is unlikely to lead to dramatic changes in the present patterns of cooperation. For various reasons, the United States would be unwilling to exclude all foreigners from the vast area it would gain under a 200-mile limit. It could exercise more authority than it does at present, but would probably still continue to reach agreements through traditional means of negotiation. The most important requirement for the future management of North Pacific fisheries is that of creating an effective and comprehensive institution that will be able to incorporate, on a gradual basis, the plethora of present ad hoc arrangements and that will be able to respond expeditiously to the newly emerging pressures. But the UN Law of the Sea Conference is not likely to deal directly with the establishment of regional institutions.

West Africa

The fisheries of the East Central Atlantic are totally different, in almost every important respect, from those of the North Pacific. Instead of a handful of States with fishing vessels, there are vessels from about 40 different countries. About half of these are coastal States, all of which are low-income, developing countries. The 20 or so distant water States fishing in the area, on the other hand, are almost all highly developed (exceptions being Cuba, South Korea, and Taiwan). Also unlike the North Pacific, the West African waters harbor large numbers of different species of fish, only a few of which are found in large populations. Furthermore there are wide differences in fertility along the coast, with rich upwelling areas off the sparsely settled desert regions, such as Mauritania and Namibia, but relatively unproductive waters off the coasts of some highly populated States, such as Ghana, Nigeria, and the Ivory Coast which are also countries from which fishermen actively explore the oceans adjacent to other countries. Indeed the accidents of geography tend to be perverse in this region, with poor resources off fishing States and rich resources off non-fishing States.

The development of the fisheries off West Africa has been extremely rapid, growing from 400,000 tons in 1958 to 2.6 million tons in 1970. More significant than the total growth, however, is its composition. Between 1960 and 1970, the catch by distant-water vessels from outside the region increased about five times, while the catch by the local coastal States rose only 80 percent. Most of the increase by non-African States has been through the use of large freezer-trawlers and factory fishmeal ships that are capable of catching and processing great quantities of fish without being dependent on nearby ports. Among these countries, the U.S.S.R. is the most active, followed by Spain, Norway and Japan. Among African nations, the largest catches are those of South Africa, followed by Angola, Senegal, Morocco and Ghana. The increase in fishing has been so large that many important stocks are now depleted or threatened by depletion. There is, thus, an urgent need for fisheries management and for the adoption of strict regulations and controls to prevent further waste. But while the general dimensions of the need can be defined, precise responses to the need are difficult to formulate because of critical lack of knowledge about most of the stocks.

Another critically important characteristic of this region is that regional cooperation on the management of fisheries is just in its infancy. The Committee for the East Central Atlantic Fisheries (CECAF) - the first and only international fisheries body for the area north of Zaire up to Morocco - has been in operation for only about seven years. For the region south of Zaire, it was not until 1971 that the International Commission for the Southeast Atlantic Fisheries (ICSEAF) was established. Both of these bodies have many members, including coastal and non-coastal States and developed and developing States. Both the size of membership and the disparity of interests are likely to impede, if not preclude, effective cooperation on management measures in these organizations, although they may be useful in the development of information.

The conditions in the West African fisheries may be significantly affected by, and may significantly affect, decisions at the Law of the Sea Conference. For example, proposals that would permit a coastal State to have exclusive rights only to the fish that its vessels can catch in its national zone of jurisdiction, while foreigners could fish for the rest up to some agreed total catch, would be virtually impossible to implement in this area. The lack of information, the large number of States with short coastlines, the migratory patterns of many species, the high mobility of foreign fleets, the disparity between factory vessels and primitive canoes - these and many other factors would preclude any meaningful calculations of degree of countries' utilization or capacity to fish within their national zones.

But the same factors also serve to create difficulties for the implementation of a fully exclusive 200-mile fisheries zone. Such a zone would permit the coastal States to control the large distant-water fleets - a control that is vitally important. It would mean that some stocks would fall within the authority of a single coastal State, thereby facilitating management, at least in principle. But a 200-mile fisheries zone would not resolve many of the other problems in the region. In fact, such a zone may encourage some coastal States to capitalize on their newly gained resources more rapidly than would be in their best interests and thus confront them with problems for which they are not yet prepared.

Among the problems facing the West African coastal States with a 200-mile fisheries zone, the most important would be that of gaining the information necessary to make regulations for management. While better information would be necessary under any regime, it would be solely a coastal State responsibility under the 200-mile fisheries zone approach. Another major problem associated with a 200-mile fisheries zone is that of enforcement. This is such an obvious problem that little need be said about it other than that costs can be reduced by cooperative arrangements among the coastal States. But even more difficult than enforcement would be the problems of allocation. The short national coastlines, together with the migratory patterns of many species, mean that many stocks would be found in two or more different jurisdictions if these are extended. This presents obvious difficulties for determining which State gets what share of stocks, or of the revenues collected from distant-water fishermen. In addition, as noted above, the pattern of richness of resources does not conform with the pattern of fishery interests. Certain African coastal States may wish to fish in the waters of others, but the others may find that the fishermen of far distant developed States are willing to pay higher fees than their African neighbors. And the allocation problem is further complicated by the presence of numerous land-locked States desirous of getting some returns from the wealth of the seas.

In short, the problems of West African fisheries are inordinately complex in every dimension. A 200-mile exclusive fisheries zone may serve to facilitate the resolution of some of these problems but it may also exacerbate others. It is not so much that the other problems can be avoided - for they must be dealt with eventually in any case - but that the adoption of an international convention for a 200-mile zone may force the pace of the problems' development at a rate greater than can be accommodated by the rate of growth in regional cooperation.

Some Other Areas

There are, of course, many other regions and kinds of fisheries than those discussed above. In the Northwest Atlantic, there are presently over fifteen States engaged in fishing these highly fertile waters. The International Commission for the Northwest Atlantic Fisheries (which has had a long history) has recently taken heroic steps to resolve the problems through negotiations and the adoption of national quota systems. As in the North Pacific, this pattern of ad hoc negotiations is likely to continue, whether or not there is a general convention for a 200-mile limit. In the Northeast Atlantic, however, the West European states have generally been greatly affected by the actions taken elsewhere and by those of Iceland. It would not be surprising, therefore, to find the States of Western Europe adopting a 200-mile zone and creating a "European Pond" running from Gibraltar to the tip of Greenland and northeast to the Soviet line, excluding the Baltic and East European States. The West Europeans then might be able to maintain their present levels of total catch from all oceans by fish from the Northeast Atlantic alone.

In the Indian Ocean, fisheries are relatively underdeveloped. It has been estimated that the catch of marine organisms might be increased five and a half times over the 1970 level. The countries bordering this ocean do not generally have infrastructures satisfactory for maintaining large fishery industries, although this may change. Only 5 percent of the catch (tuna - see below) is taken by countries outside the region. The Indian Ocean Fisheries Commission founded in 1967, with 31 members (19 in the region), has mainly collected information and facilitated development. Extension of national jurisdictions would do little to change the situation.

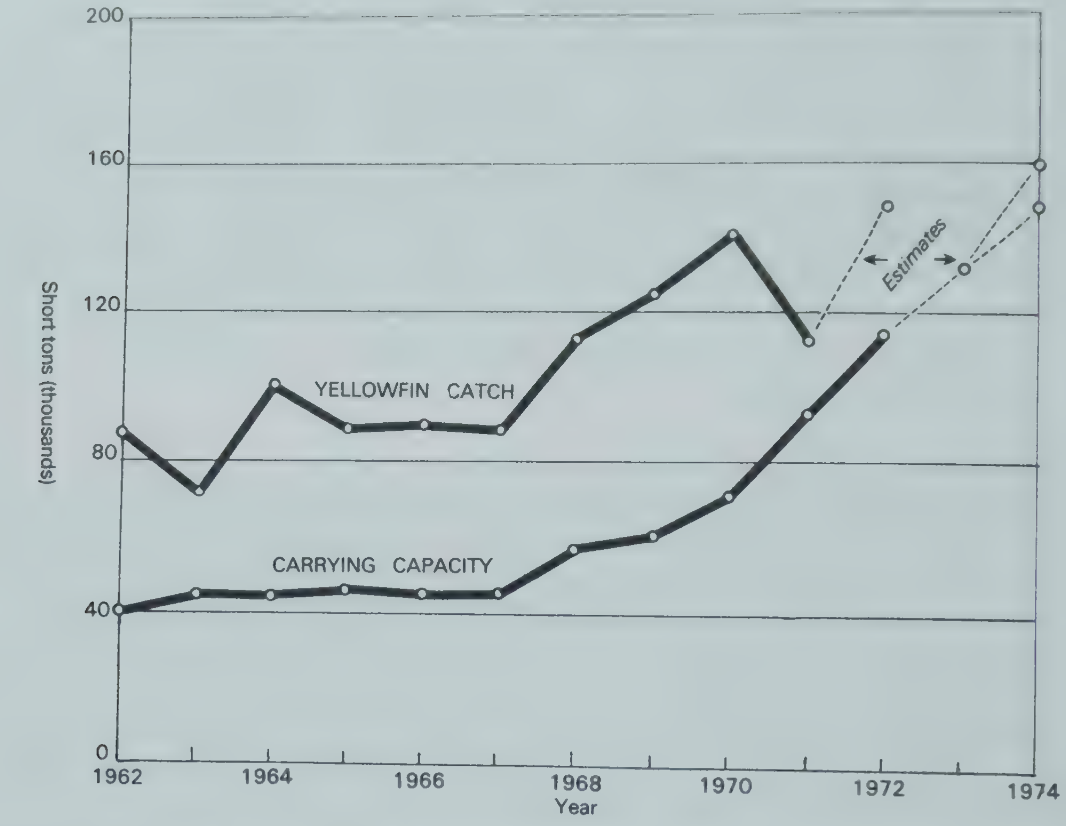
Global Tuna Fisheries

A separate discussion of tuna is included here because of its economic importance as a fishery and because its treatment on a regional basis would be inadequate. This is due to two significant characteristics. First, migratory patterns of most species of tuna tend to be very extensive - some stocks apparently covering whole oceans. Because of this, extensions of national jurisdiction, unless very great, would still leave many stocks in the international waters of the high seas during parts of their life cycles. Second, the migratory patterns of the tuna vessels are even more extensive than those of the stocks, since the larger, modern vessels are capable of traveling to all corners of the globe. Thus, regulations established in any one region have significant effects on tuna fisheries in other regions and other oceans.

Regulations will have to become much more stringent than they are at present because of the excessive pressures now being placed on the stocks of the six major species. The rapidly rising prices for tuna in the markets of the United States, Japan, and Western Europe (which consume more than 90 percent of the output) has stimulated a major growth in fishing effort. However, it is estimated that all but one of the six major species are at or near the point of full utilization in all three oceans - the Atlantic, Pacific, and Indian. Only skipjack tuna appear to afford some opportunities for increased catches, but these opportunities are limited. In less than a decade, the total capacity of the world's tuna vessels (assuming a conservative rate of increase in construction of new vessels) will probably be at or above that necessary to harvest the maximum sustainable yield for all six species in all oceans. And since fishing vessels will most likely not be appropriately distributed with regard to yields, there will undoubtedly be many areas where waste will be considerable.

International arrangements for tuna fisheries began in 1951 when the Inter-American Tropical Tuna Commission (IATTC) became operative. In 1967 the Commission put into effect a conservation control placing a total limit, or quota, on the annual catch of yellowfin tuna. This kind of control, while it is the most direct technique for conserving a stock, has very damaging economic consequences. It provides the incentive for each fisherman to build more, larger, and faster vessels in order to take as great a share for himself before the quota is reached and the season closes. In the case of the eastern tropical Pacific, the effect has been dramatic, as shown in Figure 1. The capacity of the fleet was fairly steady at about 45,000 tons until 1967. But between 1967 and 1973 it increased three times, to about 135,000 tons. Estimates for early 1974 indi-

Figure 1. Yellowfin Tuna Catch and Capacity of Fishing Vessels in the Eastern Pacific.



Source: Carrying Capacity, Saila and Norton, *op. cit.* Yellowfin Catch: *Annual Report of the Inter-American Tropical Tuna Commission,* 1972, p. 157.

cate further increases of 15 to 25,000 additional tonnage of vessels. It should be noted that the total quota and the catch was also increased after 1967, but catch only rose about 70 percent by 1972 compared to the three-fold increase in fishing effort.

Aside from the waste evident in the rapidly declining catch per unit of effort, the total quota control in the eastern Pacific has had global ramifications. The great increase in fishing effort led to a shortening of the season from the usual ten months to less than three months. As a result, the tuna vessels turn to other areas after the close of the IATTC yellowfin season, and many of them move to the Atlantic Ocean, where the International Commission for the Conservation of the Atlantic Tuna (ICCAT) is now considering regulations for the management of tuna in that ocean. Tuna fisheries are also of concern to two other international bodies: the Indian Ocean Fisheries Commission and the Indo-Pacific Fisheries Council. Neither of these, however, has adopted any regulatory measures as yet.

The problem of distributing the benefits in an acceptable manner is obviously related to the management techniques that are selected. It is apparent that the major tuna-fishing States wish to adopt a system of national quotas that would tend to preserve, insofar as possible, the present pattern of distribution of catch. But this would not generally be acceptable to the many States that are rapidly enlarging their tuna fleets, starting new tuna fleets, or intend to do so in the near future. The dilemma that this poses is compounded by the fact that, as noted above, further increases in the number of tuna vessels will not lead to commensurate increases in catches. The new entrants, therefore, will not only tend to receive poor returns for their investments but will also serve to diminish the returns to all those presently fishing. Unfortunately, the proposals submitted to the Law of the Sea Conference thus far do not appear to offer much basis for compromise.

Global Institutions

The rapid developments in fisheries together with the possibility of considerable changes in the law of the sea raise questions about the future role of global fishery institutions. From the discussion above, several trends are significant. First, there is clearly a great expansion in the need for information. This includes information on the status of fish stocks, on their patterns of migration, the interrelationships between stocks, the economic values of the fisheries, the amount of fishing effort, the characteristics of fisheries labor, and many other economic, biological, and social factors. While there has always been a need for such information, the current situation is different in two respects. The first difference is that of urgency: these days, fisheries can develop so rapidly that stocks can be depleted within a few seasons, and may actually be damaged before the need for controls becomes apparent. The second difference is that extensions of jurisdiction - to the extent they occur - mean that coastal States must assume a greater burden of responsibility for gaining information than they have in the past.

Other significant trends have similar effects. There is a pressing need for more effective regulations and for systems that facilitate rapid adoption of regulations. The global mobility of much of the new fishing effort calls for coordination between different regulatory bodies throughout the oceans. Conflicts can be expected to increase both in number and severity and will require improved methods for resolution. Finally, enforcement problems will become particularly difficult, not only if there are greatly enlarged areas of jurisdiction but also because of the likely attempts to circumvent the intent of regulations through such techniques as flags of convenience. There are, thus, greatly increased pressures for fulfillment of each of the major functions of fisheries management - research, regulation, coordination, conflict resolution, and enforcement. Of these, global fishery institutions have generally been restricted to the first - that of research. Some regional bodies play a role in the formulation and implementation of fishery regulations. Coordination of regulations between the regional bodies has not, thus far, been significant. Conflict resolution has generally been left to *ad hoc* negotiations among the interested parties. And enforcement is generally left to the coastal or flag States.

The realities of political constraints indicate that enlargement of the functions of global institutions is likely to proceed only by small increments. The most directly involved global institution is the Department of Fisheries of the Food and Agriculture Organization of the UN (FAO). Although it has devoted most of its efforts in the past to the development of fisheries, it has given increasing attention to management problems in recent years. It has fostered, sponsored, or otherwise stimulated the creation of several regional fisheries bodies and has held several conferences on management-related subjects. FAO clearly has a strong role to play in scientific research, and it may also take a stronger role in the formulation and evaluation of regulatory measures; but imposition and implementation of regulations will most likely remain the function of individual States or regional bodies. The function of coordinating activities between regional bodies is relatively new, arising from the development of highly mobile fishing fleets. FAO could play a valuable role in seeking greater coordination among the regional fishery bodies.

The role of FAO in fulfilling the function of conflict resolution is more difficult to foresee. While there are proposals before the UN Conference for creating machinery for the compulsory settlement of disputes, it is difficult to imagine that such proposals will be adopted. FAO might make use of its good auspices and other techniques for facilitating the resolution of certain kinds of conflicts. The function of enforcement of regulations is the one least likely to be fulfilled by a global institution such as FAO. These remarks are based on the assumption that stronger, more authoritative and more comprehensive global institutions are not likely to be adopted by the delegates of 150 States at the UN Conference. Even to achieve the enlarged functions described above is likely to take considerable effort as well as a cautious approach and a willingness to compromise.

In conclusion, it would appear that the decisions likely to be produced at the UN Conference will only have a limited effect on the problems of fisheries management and distribution. The adoption of an unconstrained 200-mile exclusive fisheries zone would tend to facilitate the resolution of some problems in some areas. Even in these situations, it can only be considered as a first step along a long path of extremely difficult problems that will be facing the different fisheries and fishery regions for decades to come. Nevertheless, the establishment of zones of national control is a necessary step toward the development of effective fisheries management, although it is far from sufficient as it will only be the beginning of the experience of national responsibility for many of the countries concerned.

[Extracted from "Disparate Fisheries: Problems for the Law of the Sea Conference and Beyond," Ocean Development and International Law Journal, Vol. 1, No. 4. Copyright © , 1974, Crane Russak and Co., Inc., New York City.]

Hidden Riches of Ponds

Staff of Tecnica Pesquera

[The conditions for growth of fish in ponds which are highly variable in size due to seasonality of rainfall can be quite favorable. This article describes some successful experiments in fish culture in an arid area of Mexico.]

Mexico's culture has always been linked with water in a dry land. Along with Coatlicue, the ancient Toltec goddess of fertility and death, Tlaloc, god of water, was the most powerful deity, for he was responsible for both drought and plenty. In every part of the country, water was worshipped and honored with special names and ceremonies by the prehispanic civilizations. The most beautiful Toltec paradise-after-death was an enormous marshland where one would swim, play, and sing for all eternity, accompanied by multi-colored fish and musical butterflies. Contemporary Mexico continues its battle for water in different ways and with different means, and water is still seen as a treacherous and ambivalent force which brings both catastrophe and plentiful harvests.

Mexico - a semi-desert country. The northern part of Mexico has less than 20 inches of annual rainfall, much of which falls in concentrated periods of time. Every year the rains leave tens of thousands of pools in ravines and depressions, many of which are of considerable size. These pools of water, be they temporary or permanent, could contribute in a substantial way to the supply of animal protein by the rural inhabitants, the poorest and most undernourished sector of Mexico's population. With the

Tecnica Pesquera is a Mexican journal specializing in fishery subjects. Translated from Spanish by Deborah H. Streeter.

help of simple technology and the development of organization, each pool could eventually be transformed into a small fish pond to supply many families with animal protein at an extraordinarily low cost, and with a minimum amount of labor.

Rosas' Experiments

While many biologists and technicians had recognized this potential earlier, it was Mateo Rosas, resident biologist at the limnological station at Pátzcuaro, who dedicated the past eight years to experimentation with the production of edible fish in the numerous rain ponds of the state of Michoacan. With little help from official institutions, Rosas selected nine bodies of water created by the rains in which he began to introduce, under a variety of conditions, eleven species of fish. Each pond had different characteristics, permitting Rosas to make comparisons and to draw scientific conclusions. The largest was about fifteen hectares following the rains, and the smallest was three hectares. While some were temporary and slowly dried up, others lasted the entire year varying in size in accordance with the rains and evaporation. The species he introduced were: charal, acúmara, lobina, carp, "pescado blanco," bagre, catfish, three types of tilapia fish, and, defying all established facts, rainbow trout - salma gairdneri - a species considered adaptable only to crystal clear waters which have a high oxygen content and are very cold.

The drying-up process, an advantage. The work of Rosas, as well as that of other biologists, demonstrates that temporary ponds created by rains and floods are appropriate for fish culture. Prior to such research, it was generally believed that no temporary pond was suitable for fish production; but experiments showed that the transient nature of a body of water, far from being an inconvenience, presents several advantages for fishculture. Among these advantages, Rosas points out the following: (a) When the pond reaches its lowest level, harvesting is easy, as no fish can escape. The exact rates of mortality and growth rates of the fish population that was introduced can be determined. (b) The investment in fishing gear is minimal, which is important considering that the fish are caught by the poor rural inhabitants. (c) The processes of fish culture are facilitated by the elimination of predators, fertilization, collection of species, etc. (d) Because the temporary waters are rich in nutrients, the costs of production are reduced to very low levels. (e) Newly fallen rain waters present no problems of disease.

The Results of Opopeo

Although Rosas utilized nine bodies of water and eleven species, as mentioned above, the rain pond that provided the major part of the conclusions and was considered the prototype was the one known as Opopeo. This body of water, formed every year when the rains fill a natural depression, lasts from nine to eleven months, depending on the intensity of the rains and droughts. It is located sixteen kilometers north of Pátzcuaro, at an altitude of 2, 200 meters in the region of Opopeo. After the rainfall, the pond reaches a maximum size of six hectares and will produce fish until it shrinks to one and a half hectares. The median temperature of the pond during the year is 18 degrees Centigrade, with a ph level of 7. 2, and a concentration of oxygen of 6cc. /liter. The pond has a muddy bottom and abounds with aquatic flora.

When the rains begin and the indentation in the earth starts to fill with water, an intense explosion of life goes on day after day in the depths of the growing pond, creating an optimum food chain for the species to be cultivated. Of the eleven species which Rosas initially introduced in his experiment, the only notable results were with carp (*Ciprinus carpis*) and with rainbow trout (*Salmo gairdneri*) which broke all records for growth of that species in fish culture stations. The other species introduced in the pond could not withstand the low temperatures and either did not grow or perished. The three classes of tilapia died, leaving the ichthyophagic fish such as the "pescado blanco" and the lobina without food.

The carp, however, found an ideal environment and had high rates of growth. Small carp, 3 cm. in length and 1. 5 gr. in weight, introduced in June weighed more than 800 gr. and had an average length of 33 cm. ten months later. The most outstanding results came from the trout which were only introduced in Opopeo in 1971. In the beginning of 1972, a sampling of fish turned up trout 32 cm. long, weighing 350 gr. When these fish were introduced seven months earlier, they had measured only 4 cm. For the purpose of comparison, we may mention that in the principal trout station in Mexico, the rainbow trout in its first year reaches a size of 12 cm., from 18 to 24 cm. in the second, and only at the end of its third year does it measure 30 to 35 cm. - the same size that the trout in the Opopeo pond had reached in seven months! It is calculated that the growth of trout in the pond was 5 cm. per month, due to the abundant nutrients available. The above mentioned results clearly demonstrate the possibility of using ponds as miniature fish stations, self-sufficien and productive, managed and administrated after a certain training period by the rural population itself. Equally evident is the possibilit that two competitive species, such as carp and trout, can co-exist and develop in the same body of water.

The carp and trout do not compete. With the introduction of carp and trout into the same pond, Rosas demonstrated that it is possible to produce abundant and cheap food, such as carp, which nourishes the rural inhabitants, whether consumed fresh, smoked, or salted. Trout, smaller but more valuable, can be sold in the towns and cities nearby for high prices, to improve the meager incomes of the organized peasants. The co-existence of the two species in the same pond is due to the abundance of nutrients, and because of the different eating habits of trout and carp. Only towards the end of the life of the pond do the trout encounter difficulty in locating food, because they cannot see their prey in the turbid water. This difficulty is made worse by the constant movement of the carp close to the muddy bottom in search of food. It is therefore recommended that the trout be harvested 30 days before the carp, which can continue to be nourished due to the fact that they do not need to see their food in order to catch it.

The nets which are cast into the muddied and disappearing waters of Opopeo are pulled out full of fat carp and shining trout, demonstrating the hidden riches of each pond. What matters now is that this experiment should not remain merely an item in a bulletin of information or biological thesis. It is necessary to develop further the methodology for raising fish in a pond, and to organize a government program to assure that pond stocking becomes widespread in waterholes, rain pools, and in other bodies of water formed by nature or by man. Coupled with scientific and technical experimentation should be the education of the rural population in the production and consumption of fish. If not so complemented, these exciting scientific results will be a mere biological curiosity and material for publication, while thousands of ponds and hungry peasants will continue waiting for organization that is capable of bringing to reality the remarkable experimental finding obtained from a small pond in Michoacan.

[Extracted from "La Riqueza Escondida del Charco," Tecnica Pesquera, August, 1972, pp. 18-23, Published by Ediciońes Mundo Marino S. A., Mexico 18, Distrito Federal, Mexico.]

The Ocean Food and Energy Farm Project

Howard A. Wilcox

[This article describes a novel proposal for growing seaweed on long lines under the surface of the ocean, with harvesting every three months of the seaweed and the fishes it may attract. The mechanism and the rationale for the idea are described, along with the processing and use of seaweed products. Some aspects of this proposal have been explored experimentally.]

Photosynthesis is the process by which solar energy is converted into energy stored in vegetation. The surface waters of the earth's oceans are abundantly supplied by the sun with the radiant wavelengths known to be required for the rapid growth of plants. Moreover, these waters possess copious quantities of the two major nutritional substances utilized by all photosynthesizers, water and carbon dioxide. The oceanic waters lying at depths of 1000 feet or more are generally cold and rich in nutrients (mainly potassium, nitrogen and phosphorus) required for high rates of plant growth. If these deep waters can be brought up toward the surface by artificial means, it seems likely that seaweeds adapted to the conditions of temperate waters can be grown in either the tropical or temperate latitudes. Thus these seaweeds can be utilized as relatively efficient converters of the radiant energy from the sun into the stored energy of carbohydrates, proteins and other vegetable compounds.

Processed or unprocessed seaweed can be a portion of the diets both of man and of land animals that are used by man for food. Further, some fish and

Dr. Wilcox is with the Naval Undersea Center, San Diego, California.

invertebrates eat seaweed and the encrustations that grow on seaweed, and these aquatic animals can be harvested and used as food for man and his food animals.

Seaweed, being carbonaceous, can be processed by anaerobic digestion, fermentation or other processes, into methane plus a complete spectrum of useful petrochemical-type products such as fertilizer, ethanol, lubricants, waxes, plastics and fibers. Using seaweed as a source for these products has several advantages. First, the energy used to grow seaweed is solar energy, a renewable resource. Second, the use of seaweed proportionately reduces the need for fossil fuel and, hence, the ecological problems arising from the mining and other operations associated with fossil fuel.

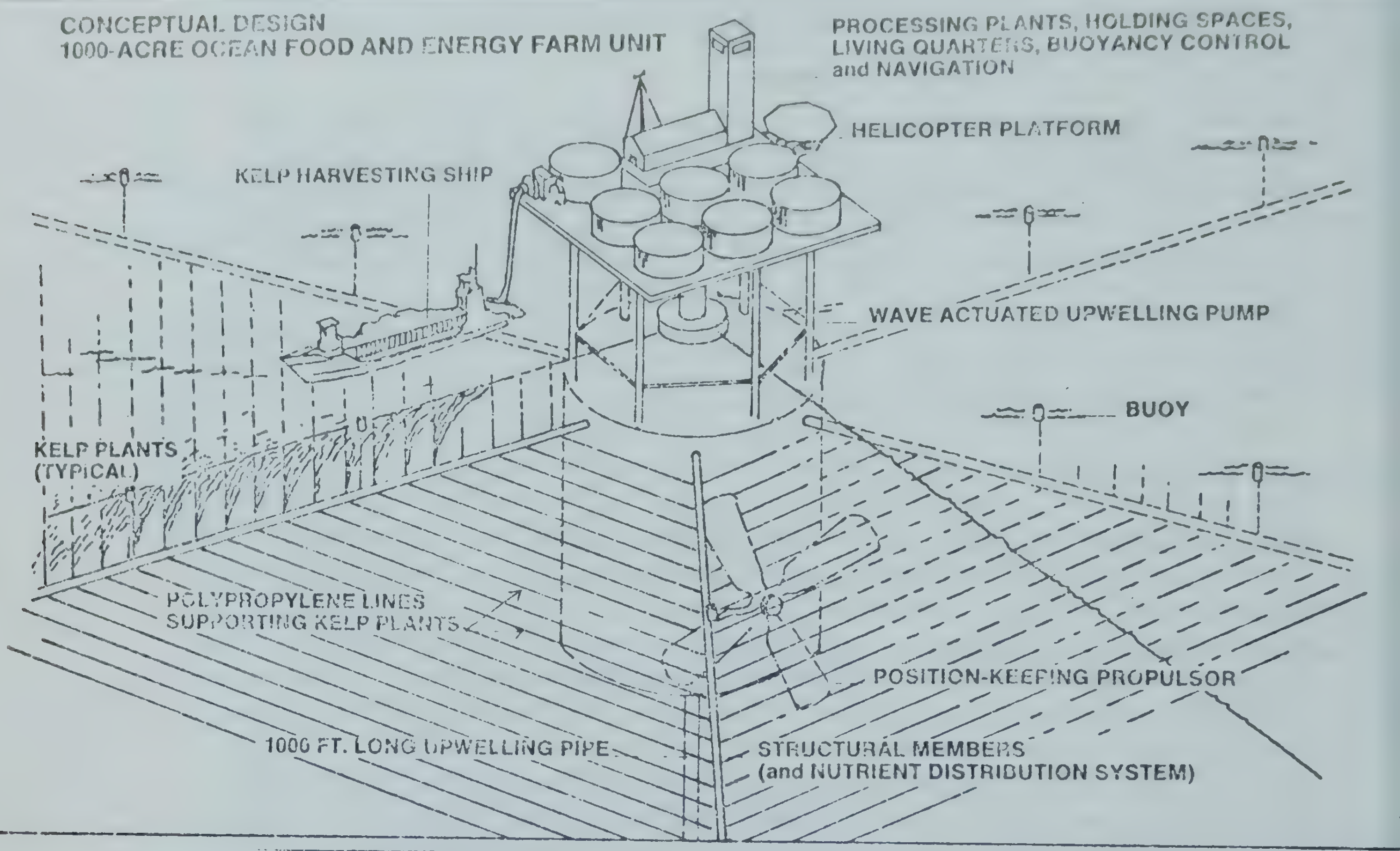
Overall Concept

Two primary problems have prevented open ocean farming in the past. First, the natural bottom is generally so deep that sunlight cannot reach it, thus preventing the reproduction and growth of attached seaweeds. Second, the surface waters of the open ocean away from shore are in most areas almost devoid of nutrient content.

The concept of the Marine Farm Project is to culture rapidly growing and easily harvested types of seaweeds on lines in open-ocean or coastal nurseries, and then transport these lines to supporting structures embracing thousands of acres and lying 40 to 80 feet below the surface of the open ocean. The water surrounding the crop is to be "fertilized" and temperature conditioned by bringing up cool, nutrient-rich waters from a depth of a thousand feet or so in the ocean (see illustration). Additional nutrients can be supplied from the farm's processing plants or from shore-based sites if such should prove to be desirable.

A portion (or all) of these plants and associated animal communities are to be harvested periodically, and the crops of seaweeds and fish are to be taken to at-sea or coastal factories for processing. The seaweeds are to be converted into foods, fertilizers, methane and other fuels and industrial materials, at the processing facilities. Separate livestock and mariculture operations may be supported with feeds derived from the seaweed.

The technical feasibility of many of the processes required by the ocean farm concept are well established, so the major issue at present is economic feasibility. If the current experiments result in a well conceived and validly engineered system design, the economic feasibility of the concept can be evaluated in terms of the cost competitiveness of the ocean farm's products compared to similar


CONCEPTUAL DESIGN
1000-ACRE OCEAN FOOD AND ENERGY FARM UNIT
PROCESSING PLANTS, HOLDING SPACES, LIVING QUARTERS, BUOYANCY CONTROL and NAVIGATION
HELICOPTER PLATFORM
KELP HARVESTING SHIP
WAVE ACTUATED UPWELLING PUMP
BUOY
KELP PLANTS (TYPICAL)
POLYPROPYLENE LINES SUPPORTING KELP PLANTS
POSITION-KEEPING PROPULSOR
1000 FT. LONG UPWELLING PIPE
STRUCTURAL MEMBERS (and NUTRIENT DISTRIBUTION SYSTEM)

products from other sources at various time periods in the future. At the present time, it seems that the concept must eventually pay off, for as land-based food and petrochemical resources become increasingly costly, marine farming will necessarily improve in its relative economic feasibility.

Preliminary Selection of Giant Brown Kelp. Based on a survey of possible seaweeds, the "giant California kelp," *Macrocystis pyrifera*, which grows along the coasts of California, Mexico, and New Zealand, has been selected for initial ocean farm feasibility studies. *M. pyrifer* is one of the world's fastest growing plants, and the reproductive cycle is well understood as it has been cultivated in the laboratory and planted in coastal areas for several years. The fronds of this plant produce numerous blades and layers of these fronds lie along the surface of the ocean to catch the sun's rays. Nutrients are absorbed from the water by all exposed surfaces of the plants.

In nature, the life expectancy of each frond is about six months, after which the old frond dies off to make way for the new fronds grow

Some of the products in which algin, the natural gum from kelp, is used today.

FOOD PRODUCTS	INDUSTRIAL	PHARMACEUTICAL
Bakery Icings and Meringues	Water Base Paints	Dental Impression Compounds
Meat Sauces and Pepper Sauces	Wall Joint Cements	Toothpaste
Beer	Welding Rod Coatings	Surgical Jellies
Ice Cream	Corrugated Paper	Mineral oil Emulsions
Delicatessen Salads	Battery Plate Separators	Tranquilizing Tablets

ing up from below. Therefore, the plant reproduces its own weight every six months or so. In the farm situation, however, the old fronds will probably be harvested every three months. Replanting of the field is not expected to be required after harvesting as the overall plants do not appear to exhibit natural aging, but plants may need to be replaced when torn away by storms, killed by disease or excessively damaged by fish grazing.

Though M. pyrifera is known to require cool water for survival, it is expected that the forced upwelling of cool, nutrient-rich deep water produced by the farm system will enable it to be cultivated even in tropical oceans. Assuming a spacing of some ten feet or so between plants, the farm will support about 436 plants per acre. Each acre is expected to yield about 300 to 500 wet tons of harvested organic material per year.

Kelp Support Subsystem. The concept calls for constructing a mesh which would be placed 40 to 80 feet below the ocean surface, and various mesh structures and positioning systems are being considered. An artificial upwelling system will also be needed, and although a final design has not been decided on, it is calculated that the system will require relatively little power - probably less than one horsepower per acre-foot of water per day. This power can probably be provided by harnessing wave or wind energy; once the total project is in operation, some of the farm's own energy yield could also be used to power the upwelling system if necessary.

Kelp Harvesting. The kelp canopy will be harvested by special vessels which will move over the farm and cut off the upper portions of the fronds. Some preprocessing, such as removal of water from the kelp, may be done on the ships before transferring the kelp to the processing plants. If fertilizers are provided in addition to (or instead of) supplying nutrients from deep water by artificial upwelling, the harvesting ships may also be used to carry and dispense fertilizers. Kelco Co. of San Diego, California, currently uses special ships for their commercial harvesting of M. pyrifera, and adoption of their design will be evaluated.

Conversion of Kelp to Industrial Products. The intent of the Ocean Food and Energy Farm Project is to develop a variety of products from the harvested kelp to provide flexibility during system growth and market integration. Also, marketing a wide range of kelp products will reduce the cost of each. Kelp is already used in a number of industrial products, and this project will focus mainly on exploring the possibility of producing food for animals and people, methane gas (CH_4), ethanol (C_2H_5OH), fibers, and fertilizers. Processing will be geared toward a mix of products that provides a high return on investment.

It will be uneconomical to transport the wet kelp great distances, so some dewatering of the vegetation will most likely be done at sea. In fact, for remote ocean farms it will probably be desirable to have the whole processing subsystem on a sea-based platform. The processing subsystem can be powered by either environment power (direct solar energy, wave action or wind power), or by utilization of some of the fuel products of the facility. Current concepts for processing the kelp will be revised as appropriate, but right now it looks as if processing will be along the following lines.

The harvest will be prepared by passing it first through warm water to remove the surface coating of fucoidan, and then by coarsely chopping it. A weak solution of calcium chloride may be used to break down the cell structure to facilitate the removal of water and salts. A separation step may be used to segregate the electrolytes and carbohydrates, then the solids and carbohydrates will go through a hydrolysis process to further break down the polysaccharides, proteins, cellulose and bonded salts.

The soluble sugars pressed out after hydrolysis will be fermented to yield ethanol and a yeast feed. The primary solids pressed out after hydrolysis will go into anaerobic digesters where methane gas will be produced. A sludge, high in nitrogen, will also result, and this can be used as a fertilizer. Alternatively, the primary solids may be used directly for animal feed or processed by Bergius conversion, Fischer-Tropsch synthesis, or enzymic recycling (hydrolysis) to yield other products.

Conversion of Kelp to Human Products. In nature, kelp stands shelter and support abundant faunal communities, with the larvae of small animals attaching themselves to, and then growing on, the kelp. They obtain nutrition by filtering plankton out of the water. Fish, in turn, graze on the kelp, presumably digesting those encrustations, but also obtaining some sustenance from the kelp vegetation or the plankton in the water. Such fish as opeleye perch and halfmoon naturally inhabit the coastal kelp beds off California.

In the ocean farm, the fish population should be easy to harvest. Open spaces will be left in the kelp fields, nets will be lowered into these areas, and the fish will be lured over the nets by chumming, use of an electric field, or use of flashing lights. The open ocean farms may be stocked with fish such as the opeleye and halfmoon, or it may be found that open ocean species will naturally collect in the cultivated regions.

Another approach for converting the kelp into food products is to feed the vegetation or its derivatives to fish, abalone, sea urchins, snails or other invertebrates in separate mariculture operations. Additionally, kelp derivatives can be converted to human foods by feeding them to land animals such as sheep and cattle. Further, a two-step conversion of kelp to human foods via insect larvae consumption followed by poultry or fish consumption may be practical and will be investigated.

Overall Development Plan

Tentatively, three project phases are planned for the Ocean Food and Energy Farm Project. The first phase, the proof of feasibility, is expected to take three to four years at a cost of some \$3 to \$4 million (dollars at 1974 values). During this phase investigators will prepare design concepts, demonstrate the feasibility of concepts, test subsystem models, place and study operation of two or three small scale farms, study problem areas, integrate subsystems, and perform operations and economic analyses.

The second phase, the proof of concept, is expected to take four or five years at a cost of about \$48 million. During this phase investigators will engineer and fabricate a culturing facility for small kelp plants, kelp farm structures, and a harvesting subsystem, and install two farms, one in the Atlantic and one in the Pacific, each of a size tentatively set at 1000 acres. They will also engineer and fabricate food, fuel and industrial material conversion facilities, and evaluate at least one year's operation of the two farms and processing facilities. The third phase, a full scale farm, estimated to take five to six years at a cost of about \$1.9 billion. During this phase investigators will enlarge culturing facilities, assemble a farm system tentatively set at 100,000 acres, and engineer and fabricate a correspondingly large capacity harvesting system and processing plants. A seven-acre experimental farm was successfully placed in exposed weather and sea-state conditions about 1000 yards off the northeastern tip of San Clemente Island, California, where the water is 300 feet deep. Between 100 and 150 M. pyrifera plants were taken from the nearby natural beds and attached to the farm, but no attempts were made to provide nutrients to the plants. Results indicated the kelp survival rates were very high and that the kelp reproduced well on all ropes and buoys of the farm. The natural nutrient levels in the ambient water were rather low, so both the natural beds and the farm showed relatively low growth rates. A combination of accidents, however, resulted in the total destruction of this farm unit late in January 1975.

Facilities have been prepared, reference data have been collected, and methane production has been achieved. Sheep, snails, abalone and fish have been started on kelp feeding trials, and results to date show sheep digestion efficiencies of 58 percent of the organic matter in the dried kelp - about the same as for the base ration composed of alfalfa hay, oat hay, barley and sodium phosphate.

The future. Assuming a two percent conversion efficiency for converting solar radiation into the stored energy of seaweed compounds, five percent conversion efficiency for the production of human food from the seaweed, and 50 percent conversion efficiency for the production of other products from the seaweed, the marine farm concept is "conservatively" projected to yield enough food to feed 3000 to 5000 persons per square mile of ocean area cultivated. At the same time it will yield enough energy and other products to supply more than 300 persons at today's U. S. per capita consumption levels, or 1000 to 2000 persons at today's world average per capita consumption levels. Since the oceans appear to contain some 80 to 100 million square miles of "arable surface water," this means that marine farms could conceivably supply a human population ranging from 20 to more than 200 billion persons, depending on the degree of affluence assumed. But before any such vast undertaking could be put into operation, of course, close attention and studies will have to be given to the possible problems of environmental degradation, societal upset, and legal/political difficulties. Some of these studies have already been started.

[Extracted from a supplement to Calypso Log, Vol. 3, No. 2, 1976. Published by The Cousteau Society, Inc., Los Angeles, California. The original article was adapted from an address by Dr. Wilcox to the International Conference on Marine Technology Assessment, Monte Carlo, October 1975.]

NERGY AND AGRICULTURE

USERS OF ENERGY IN MEXICAN AGRICULTURE:
THRESHER, TRACTOR, AND TRUCK
(PHOTO: INTER-AMERICAN DEVELOPMENT BANK)

Energy and Agriculture: an Editorial Introduction

The three articles which follow are exploring an area which is receiving increasing scientific attention but which is currently in a state of flux and controversy among specialists. On the one hand, it is a field in which a great deal of scientific knowledge has been accumulated concerning the agronomy and the basic physics, chemistry and biology that are used for building blocks. On the other hand, the combining of knowledge from these different disciplines is so complex that wide differences in results can follow from the assumptions that are used.

Agriculture is both a user and a producer of energy. A subsistence farmer uses the energy of his family and his draft animals to grow crops; and crop growth also depends on the process of photosynthesis, which converts energy from the sun into vegetable matter (solar energy is the ultimate source for all man's traditional energy forms). The crops, in turn, produce energy in the form of food calories. In subsistence farming, much of this is recycled back into the farm: food for farm workers and animals, and for the wife and children whose needs must be met if the farm is to continue. In addition, support of the farm's activities requires other forms of energy: for cooking, and heating in cold weather, which may derive from the solar energy going into the growth of trees to supply wood; and for farm tools, houses and furnishings which embody energy from wood or other sources. If tools and cooking pots are of metal, then energy has been used to extract the metal and shape it, and to move it to the farmer; and energy goes into production of cotton or wool and the fabrication and transport of clothing. Even if all these products are made locally by handicraft methods, the labor time implies food inputs for workers' families, and the materials imply energy inputs of several kinds.

The energy accounting becomes even more complicated when one moves from subsistence villages to the many ramifications of modern commercial farming. Here a farmer will "export" energy (calories) to the market by crop sales, and "import" a variety of goods embodying energy inputs from distant factories. Many of these imports will be consumer goods, each with its own energy inputs too various to mention. More important for this analysis, the farmer's ability to export energy depends on his use of imported energy to raise the productivity of his land with such inputs as fertilizer (using natural gas- or petroleum-based nitrogen, along with other materials), farm machinery (metals, fabrication, etc.) and the fuel to run it (gasoline or diesel oil). If the farmer raises cattle, pigs or poultry by modern methods, he will need specialized feedstuffs (calories derived from acres of other people's cropland, or from fishmeal) to maintain his productivity - another chain of energy inputs and outputs leading to further inputs. All these inputs have made possible the gains in farm production which enable the world to feed its growing populations and raise living standards generally; and population trends as well as development aspirations point to a need for further accelerating this flow of energy into agriculture.

The recent "energy crisis" - high oil prices, foreign exchange problems, materials shortages - has dramatized the question of energy supplies. While some aspects of the "crisis" may have been temporary or accidental, there is no doubt that it brought the general subject forcibly to many people's attention around the world, and that it has stimulated a great deal of questioning of the assumptions about energy supply and a new search for energy alternatives. Specialists who had been thinking about these matters for years have found a newly enlarged audience, and novel ideas are being introduced. Agriculture is only one of many aspects of energy use, but one of the more important.

The basic problems in supplying energy to agriculture have a physical and an economic dimension. "Crisis" has brought attention to possible physical shortages of the mineral fossil fuels (oil, gas, coal) which have provided the rapid acceleration of energy inputs to date, and there is much debate on how long these resources will last. Without entering that debate, it is at least clear that such resources are non-renewable; and it seems likely that they will continue to cost more than in the past, whether or not higher prices are directly caused by current physical supply conditions. It seems improbable that agricultural productivity in the developing countries could be raised by a worldwide application of the high levels of fossil fuel inputs per acre, or per man, that are common in industrial countries; world supplies of these fuels would not permit such levels of use for many years under the most optimistic estimates. The next article by C. P. Timmer analyzes the economic constraints on the widespread introduction of fossil fuel energy into developing country agriculture under current and probable conditions. The second article by Gerald Leach documents the intensity of energy use that has evolved in modern agriculture, both in its methods of production and in the kind of products it supplies to meet the demand for food in industrial countries, and notes some implications.

Agriculture, however, is a producer as well as a consumer of energy. And the energy it produces is renewable in that it comes in large part from the vast current inflow of solar energy. This is unlike the fossil fuels, which embody energy that originated in the solar inflow over millions of years, and which are not being created at anything like present rates of depletion. Thus, agriculture may be regarded as an energy source which could in time become more attractive as the costs of fossil fuels rise. It might provide the energy inputs for a growing agricultural sector, and perhaps even a surplus for other sectors. The somewhat unfamiliar technologies for doing this may have their first economically justified applications in the non-oil-producing developing countries, whose demand for food is great but whose purchasing power in world markets is limited. The third article, by Arjun Makhijani, presents proposals for using this kind of technology, illustrating its economic potential under conditions of an Indian village; the possibilities are not limited to India.

In these articles, as in others on the subject, frequent reference is made to units of energy required in various activities or embodied in various materials. Several kinds of unit are used, and although defined in different ways (as units of heat, mechanical work, electric power) they are interrelated. The joule, a unit of mechanical work, is related to the electrical watt: 1 watt = 1 joule per second; 1 kilowatt hour (kwh) = 3600 kilo-joules (kj). Another unit is the British thermal unit (Btu), a unit of heat, which is approximately equal to 1,000 joules (1kj). Calories are also used: 1 cal = 4.186 joules = .003968 Btus. (The calorie used for food energy is 1,000 times the "small calorie" just defined, and is properly termed a kilogram-calorie, or kcal, as opposed to the gram-calorie.) Large numbers of these units are designated as follows:

Kilo - = 1,000 units (e.g., kj, kcal, kw)
Mega - = 1,000,000 units (mj, megawatt)
Giga - = 1,000,000,000 units (gj)

Units of energy are also commonly expressed as equivalent (in Btus or joules) to that embodied in a quantity of coal or oil.

The energy efficiency of an activity or process refers to the percentage of energy emerging in a desired form (e.g., Btus in the kilowatt hours of electricity) compared to that used to produce it (e.g., Btus in the coal burned in electric generators).

Gordon Donald
Editor, Development Digest

Interaction of Energy and Food Prices in Developing Countries

C. Peter Timmer

[The economic relations involved in the introduction of fossil fuel inputs into agriculture in developing countries present some formidable obstacles to this important type of innovation. This article examines the supply and demand relationships, and notes some discouraging implications.]

Food is man's energy, but the production of that food requires energy inputs from outside the food system. Most of this energy input, even in highly commercialized agriculture, is from the sun and hence is "free.' But this should not cause us to lose sight of the fundamental inefficiency involved in converting one form of energy into another. The secret is to find a cheap form to convert into a more expensive one. For agriculture, solar energy is the cheapest of all; but natural gas converted into nitrogen fertilizer, or petroleum converted into diesel fuel converted into rotary motion in an internal combustion engine converted into irrigation water, might also meet the cheapness criterion.

The criterion is economic, not technological. Whether it makes sense to convert five calories of fuel energy into only a single calorie of food, which is the energy input-output ratio calculated by the Steinharts for U. S. agriculture, depends on the relative price of food to fuel (among other things). This economic triviality has frequently been ignored in some of the more alarmist talk about the relationship between the "energy crisis" and the "food crisis."

Dr. Timmer is H. E. Babcock Professor of Food Economics, Cornell University, Ithaca, New York.

Some reputable technologists are seriously advocating the use of energy input-output ratios as the major factor in choosing agricultural production techniques (Pimentel, Lynn, McReynolds, Hewes and Rush). Such technological reasoning implicitly invokes an "energy theory of value" and leads inevitably toward labor-intensive, land-extensive agriculture and away from mechanized, irrigated, artificially fertilized agriculture. "For example, in Mexic[an] ax and hoe corn culture . . . a total of 1,144 hours of labor was required to raise a hectare of corn. Other than manpower, the only inputs were the ax, hoe, and seeds. By this method the yield in kcal of corn per input kcal was 10.13. The energy ratio is more than four times the U.S. average of 2.5." (Pimentel, et al., p. 6).

Mexican "ax and hoe" agriculture will not solve the "food crisis;" it is part of the problem. Modern, energy-intensive agriculture is the only hope for many of the world's present population and for most of its yet-to-be-born. Changing crop mixes, wider use of green manures, and more efficient use of energy in intensive agriculture are also possible. But the central point remains: to produce the food supplies needed for adequate nutrition in rich and poor countries alike, the only hope in the next few decades lies in energy-intensive agriculture.

This conclusion raises both technical and economic issues. First, is the energy available to convert low yield agriculture to high yield agriculture? Roger Revelle estimated the energy that would be required in a modernized, irrigated agriculture and food processing system in India. He included energy for the construction and operation of flour and sugar mills and cold storage plants but not energy for cooking and food preparation in households. Revelle's calculations show that the food energy obtained would be about twice the mechanical energy utilized, in spite of the large amount of energy used to pump groundwater for irrigation.

> For the present average Indian diet of 2,150 kilocalories per day, 410,000 kilocalories of fossil-fuel energy per person would be required each year, equivalent to 55 kilograms of coal, costing at 1974 prices, $2.50. That is about a fourth of the per capita use of fossil-fuel energy in India today. For a future diet of 3,700 kilocalories of primary plant materials and a population of 1.2 billion people, instead of the present 580 million, the total energy requirement for agriculture would be the equivalent of 95 kilograms of coal per person, or a total of 114 million tons per year. Estimated reserves of fossil fuels in India are between 100 and 1,000 tons per person. Hence if India relied on her own fuel reserves, enough energy would be available for a modernized agriculture for several hundred years.

Table 1 reproduces Revelle's calculations.

Table 1. Food-Energy Yield versus Mechanical-Energy Use for a Modernized, Irrigated Farming and Food Processing System in India

	Millions of Kilocalories		Ratio of Mechanical Energy Used to Food Energy Produced
	(per hectare)	(per ton of food grains)	
Irrigation from wells	3.75	0.585	0.167
Chemical fertilizers	3.01	0.469	0.134
High yielding seeds	0.15	0.023	0.002
Plant protection	0.05	0.008	0.002
Farm tools and machinery	1.05	0.164	0.047
Fuel for machinery	1.97	0.311	0.089
Fuel for drying crops	0.30	0.047	0.013
Transportation	0.18	0.028	0.008
Storage and marketing	0.05	0.008	0.002
Food processing	1.25	0.195	0.056
Totals	11.76	1.838	0.525

Source: Revelle, p. 165.

Note: The table assumes a harvest of 6.4 tons of food grains per hectare, equivalent to the average harvest of corn in Iowa. At present the average Indian farmer produces only about a ton of wheat or rice per hectare. Irrigation and fertilizers together account for about 65% of the energy that would be required directly on the farms to bring about the sixfold increase in yield.

Despite the apparent cushion of Indian fossil fuel supplies relative to the needs of a high yield agriculture, Revelle emphasizes that these provide only short-term promise. Development of the rest of India's economy, commensurate with a modernized agriculture, will also be energy-intensive. Fifty years from now India and most other countries will have to rely mainly on non-fossil-fuel energy sources - probably nuclear and solar - for the great bulk of their energy requirements. The pressing issue is what happens in the interim.

[Omitted from this extract are equations for a macroeconomic model relating the (low) price elasticity of demand for food in countries like India to the use of fossil-fuel-based inputs to agriculture for increasing food production, considering production functions and market-clearing equations. The results suggest that food prices will have to rise in the long run to maintain the profitability of energy-intensive farming under probable conditions when fossil-fuel prices rise.]

The model has direct relevance to the present energy-food situation. The feedback effect of low consumer response to changes in food grain prices, to the equilibrium prices for these foods, and hence to profitability conditions with respect to the use of high yield-producing energy inputs into food grain production, is too powerful to ignore. The essence of the message is that energy inputs must be profitable to use. If they are not, then relative food/energy prices must rise until profitability is restored.

Most energy applications in the food growing process, primarily in fertilizer and pumped irrigation water, are made prior to the time of harvest and sale. When energy prices go up, applications go down, and the resulting diminished harvest does not have an upward effect on food grain prices until several months later. The system is recursive. Since few farmers plan their input use with full knowledge and understanding of the recursive nature of the production-price formation system, several seasons will be needed before a new equilibrium can be reached after an exogenous energy price change disturbs an old equilibrium. Indeed, given the significant lag on the energy supply side with respect to price (primarily for fertilizers, but the search for oil is price responsive as well), and the great desirability of positive energy supply response to assure that convergence occurs mostly through greater food output when food prices rise rather than by reduced food consumption, the short run adjustment may last as long as five to eight years. This gives sufficient time for the fertilizer industry to put in place new investments in the face of a new price environment.

Different short-run supply responses for fuel and fertilizer should also be mentioned. Although total world fuel supplies may no longer be significantly price responsive in the short run, supplies available for agricultural use probably are price responsive. This implies an ability of agriculture to bid away supplies from other sectors, an ability that will come only through better relative prices for agricultural products.

Supply response for fertilizer is a considerably more complex issue. The fertilizer industry has been through several cycles of boom and bust, and there is a real danger that governments, corporate executives, and industry analysts will now seriously underestimate the future demand for plant nutrients because of past experience with overexpansion. Underestimating future demand by much will seriously prolong the present short-run disequilibrium and cause widespread hunger.

Part of the conclusion from the model that energy applications "must" be profitable stems from the ceteris paribus treatment of non-food-energy variables. Freeing them from this immobility alters the conclusion to some degree. In the demand equation, income and population growth can only add to upward pressures on food prices, other things being equal. Introducing these variables strengthens the conclusion that energy inputs into food production will require rising food prices because the demand function will be shifting outward.

A contrary effect is felt when other variables in the production function are freed. As the price of food rises to make energy inputs profitable to apply, more intensive application of all other inputs becomes more profitable as well. The driving mechanism of the model is considerably weakened if substantial scope exists for expansion of food output through the application of nonenergy inputs. Indeed, if more acreage is available, more labor-intensive cultivation rewarding, better water control and use more feasible (without pumps), and so on, then the reliance on energy related inputs to meet the demand for food will be substantially weakened. The extent to which nonenergy options exist for raising food output will depend on individual national (and regional) circumstances. But even where they exist, food prices must rise to call them forth. The more general lesson is that food production must be profitable in the long run.

It is easy enough to say that food prices must rise relative to energy (and other input) prices so that growing food remains profitable. What is ignored in that statement is a consideration of the social and political costs involved in the process. Only the commercial farmer is fully protected on the income side in such a world, and even he will have to pay higher real food prices. Subsistence farmers who sell little food will benefit little from its higher price. The nonfarm poor are obviously the worst off. With no landholdings at their disposal to produce some of the high priced food for their own use, the nonfarm poor must find a means to buy their entire food requirements. This usually means cutting back on nonfood expenditures, but since many of the urban poor spend nearly all their income on food already, this offers little hope. A second alternative is to find additional sources of income. But the very logic of the model, that food prices must rise relative to other prices, will make this a frustrating effort. The final solution, grimly final in several countries, is a reduction in food intake and slow starvation for those already on the margin. The political implications, both domestically and internationally, are only now beginning to be seen.

[Extracted from American Journal of Agricultural Economics, Vol. 57, No. 2, May 1975, pp. 219-224. Copyright ©, The American Agricultural Economic Association, 1975.]

Energy and Food Production

Gerald Leach

[Food production in the industrialized countries is heavily dependent on inputs of energy from fossil fuels. The author analyzes these inputs with particular attention to the UK, and presents a wide range of data on the total energy used and how this relates to factors such as outputs, labor and land. He emphasizes the importance of low energy alternatives for Third World countries.]

Recently several studies have asked how much energy is needed for food production, and they have produced answers that are remarkable and rather perturbing. Broadly, they have shown that while most traditional farmers achieve high food yields per energy unit invested, the industrialized food systems of the West have raised food yields and quality and cut labor usage, but have done so by heavy consumption of - and dependence on - fossil fuels. Most developed societies now use 7 to 8 units of fossil fuel energy for each food energy unit consumed, or an annual 0. 8 tons of oil equivalent per person.

These energy subsidies have helped transform working conditions and living standards in modern societies, especially on the farm. They are also a natural response to a period of high wages and cheap energy. Their emergence is easily explained. Yet they do raise several important policy questions for the future. Not least of these are whether recent trends in the energy-intensive food systems of the West need to be reversed, or can be without harm; whether they are a possible model for the

Gerald Leach is a Fellow of the International Institute for Environment and Development, London, England.

developing world to copy; and if not, what energy-food strategies can do most for the energy- and food-hungry majority of the world's people

The Energy Analysis Approach

This article presents a wide range of data relevant to these questions by focussing on the total energy used in food production and how this relates to other cardinal factors such as outputs, labor and land. Before doing so, three things must be said about the method and limitations of energy analysis. First, though it deals with a uniquely important resource, it is merely a descriptive science. It is a complement to, not a replacement for, economic or other valuation systems. Second, food production displays such wide variations of outputs and inputs due to climatic, soil, water, management skills and other factors that the energy analysis of food production is at present mostly limited to broad statements about averages. The average data presented here should be treated with this in mind. Third, and most important, energy analyses themselves vary widely in quality. Tracing all the direct and indirect energy inputs to a crop or national food production system is a formidably demanding task. Some approximations must be used, and some authors have been a good deal more approximate than others. This article relies heavily on the author's own study which examines the UK food system in detail with a consistent accounting method and set of data, and applies these to other food production systems.

The Input Range

Table 1 shows that energy requirements for a unit of food energy or protein vary by roughly 10,000 times as one spans the entire spectrum of food production systems. For the subsistence and hunter-gatherer communities of the first three entries the Energy Ratio (output/input) is consistently high, thus achieving a traditional aim of agriculture, which is to secure a net energy flow to man. With industrial systems much more energy is needed per unit of output, with animal products and sea fishing requiring consistently higher amounts of energy than crops, as one might expect. This last fact does much to explain why,for the total farm systems of the UK, USA and Holland,the Energy Ratio is always less than one and as low as 0.3. The Table also shows for the UK and Holland a strong trend towards greater energy intensity in agriculture in the last 20 years. When one includes the entire food production and delivery system to the point where food is sold in shops the Energy Ratios in developed societies drop to around 0.2, giving an annual fossil energy requirement of about 24 GJ or 0.56 tons oil equivalent per capita. In most developed societies a further 5-10 GJ per capita is used in transporting food to the home and in the home for cooking, refrigeration, etc. [Note: in this article the energy unit used is the joule. MJ = 1 million joules; GJ = 1,000 MJ, roughly equivalent to 1 million Btu.]

Table 1. Range of energy ratios for food production systems

Farm gate or dockside	Energy out / Energy in	Energy in / Protein out (MJ/kgP)
Chinese peasants 1930s	41	3·6
Tropical crops, pre-industrial*	13-38	4-13
Tropical crops, semi-industrial*	5-10	15-80
Wheat, UK 1970	3·4	42
Maize, USA 1970	2·6	62
Potato, UK 1970	1·6	96
Allotment garden, UK 1974	1·3	58
Rice, USA 1970	1·3	143
Milk, UK 1970	0·37	208
Eggs, UK 1970	0·14	353
Poultry meat, UK 1970	0·10	290
Shrimp fishing, Australia 1974	0·06	366
All fishing fleets, Malta 1970-71	0·04	420
Fishing, Adriatic 1970-71	0·01	1770
Yeast on methanol 1974	–	170
Yeast on N-paraffins 1973	–	195
Winter tomatoes, Denmark (134 MJ/kg)	0·004	14900
Winter lettuces, UK (230 MJ/kg)	0·002	26100
All Agriculture UK 1952	0·46	251
1968	0·34	326
1972	0·35	315
USA 1963	0·87	158
HOLLAND 1950	0·91	
1960	0·53	
1970	0·30	
Total food system to shop door		
UK 1968	0·20	796
USA 1963	0·22	616
1968	0·19	
1970	0·15	
AUSTRALIA 1965-69	0·14-0·20	

* Pre-industrial systems have more than 95% of energy inputs in the form of muscular work by men or animals. With semi-industrial systems the proportion ranges from 10-95% but is usually 40-60%, the remainder being fossil inputs mostly for fertilisers but with some machinery and fuels. All other systems shown are full-industrial, with muscular effort accounting for less than 5% of the total, and usually less than 1%.

Energy and Labor

An important consequence of the high energy ratios of 'primitive' farming systems is that labor requirements for food supply are not abnormally high, despite popular mythology. With an Energy Ratio of 25 a subsistence farmer need spend only two hours per day on average in order to feed a family of four with a combined food energy intake of 40 MJ per day. This figure is comparable to those of Western societies, where roughly 25-30% of household incomes are spent on food and drink.

Table 2 makes this comparison more explicit by comparing food energy yields per man hour of labor. Most non-industrial cropping systems achieve 10-20 MJ per man hour for raw food delivered to the home. With full-industrial crops this productivity soars to around 3000-4000 MJ per man hour of on-farm labor with food delivered to the farm gate. But these high outputs are then dissipated in two ways. Much of the crop is fed to animals, which reduces the productivity enormously. It is down to 50-170 MJ per man hour on most average UK livestock farms, for example. The second loss occurs when one includes all the other sectors of the food system. The total direct and indirect labor force in UK food production and supply is estimated at close to three million workers of whom less than half a million are farmers, and probably a further one million providing food and feed imports. On this total, the labor productivity is as low as 35 MJ per man hour.

Table 2. Food energy outputs per man hour of farm labour

Agricultural system	**Output** (MJ/man hour)
Pre-industrial crops	
!Kung Bushmen, hunter-gatherers	4·5
Subsistence rice, tropics	11–19
Subsistence maize, millet, sweet potato, tropics	25–30
Peasant farmers, China	40
Semi-industrial crops	
Rice, tropics	40
Maize, tropics	23–48
Full-industrial crops	
Rice, USA	2800
Cereals, UK	3040
Maize, USA	3800
Full-industrial crops plus animal	
Sheep, cattle, pig and poultry, dairy farms, UK	50–170
Cereal farms, UK (small animal output)	800
UK allotment garden, approx.	4·3
UK food system, approx.	30–35 (all labour)

This is a notable figure in view of the frequent claims that modern methods allow one farmer to feed 60 or more people. These methods depend on, have allowed, and indeed largely caused the vast social changes - including urbanization and the factory system - which have put large distances between the field and the mouth in every sense and greatly swelled the ranks of non-farm workers in the food system. In fact the average worker in the overall food system in the UK feeds only 14 to 16 people - a figure that is typical of the middle to upper range for preindustrial farmers when one counts actual working time.

This comparison does not allow for important differences of climate, food quality, supply reliability, and working conditions.

The UK Farm System

A greater insight into food-energy relationships can be gained by looking at the changing patterns of one country. Here I examine the UK, where modern farming methods and a modern industrial-urban food supply structure have evolved to a greater extent than in most countries. As late as the 1920s, UK farming was a pre- or semi-industrial system, with only 10,000 tractors compared to 410,000 today and an average fossil energy input of a mere 100-150 MJ per hectare year compared to 9,000 MJ in 1970. Only 6% of farms had a power supply, and their combined consumption was less than 1% of present levels.

The transition to full industrialization occurred very rapidly and mostly in the 30 years since World War II. Figures 1 and 2 give a rough guide to the scale and pace of these changes. In England and Wales (Figure 1) the number of farm horses declined precipitously, releasing 10% of the total farmed area for food production; whole-time farm workers fell in 50 years from nearly 700,000 to 260,000; and the tractor population rose to about 350,000. At the same time, while crop yields rose to roughly double their 1900 level (Figure 2), consumption of energy-intensive chemical fertilizers soared.

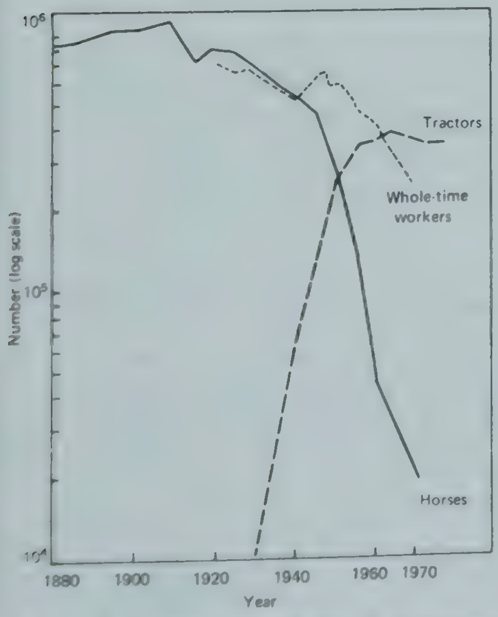


Figure 1. Number of farm horses, tractors, and full-time workers in England & Wales, 1880-1973

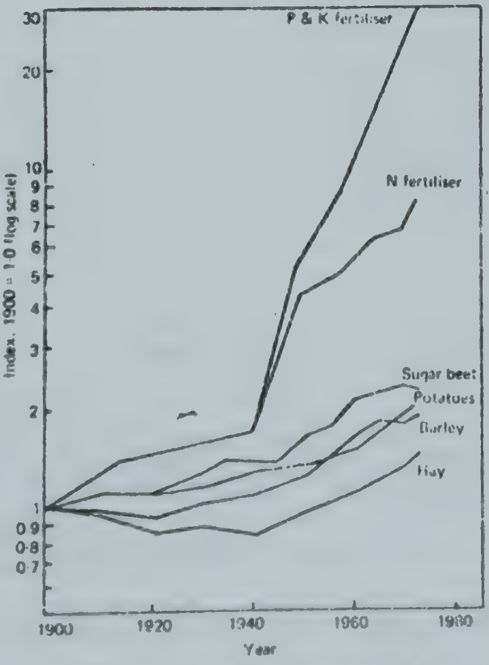


Figure 2. Fertiliser tonnages and crop yields in the UK, 1900-1972

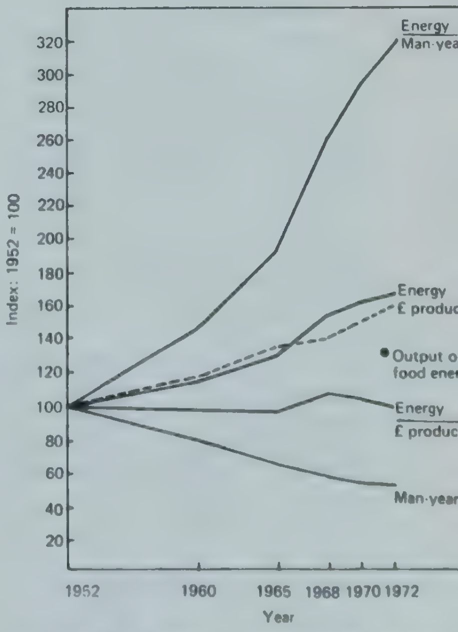


Figure 3. Energy, manpower and product, UK agriculture 1952-72

The effects on energy consumption were substantial. From a very low level at the start of the century, by 1968 the energy input to UK farming had risen to 378 million GJ, equal to 4.6% of UK primary energy consumption in that year. Of this total, 108 million GJ represented fuel and power, 82 was fertilizer, 84 was for machinery, buildings, transport and various services, 53 for agricultural imports, and 51 went into food industries to process animal feedstuffs. For this investment, among others, farming delivered 130 million GJ of food energy and 1.16 million tons of protein for human consumption - enough to feed exactly half the population in terms of calories and 62% in terms of protein.

From 1952 to 1972 total energy input to food production increased by 70% from 241 to 410 million GJ, nearly twice as rapidly as gross UK fuel consumption which rose 40% in the same period. Figure 3 shows how this increase of energy related to other factors of production. The value added or "£ product" of agriculture rose (in real terms) more or less in step with energy inputs, so that energy used per pound sterling remained roughly constant. Since the cost of fuels and power declined in real terms, it became more and more profitable to substitute energy for other basic inputs, especially labor. However, while value added increased substantially, nutritional food outputs increased far less: during the period the output of edible food for humans rose by 30% in terms of energy and 35% in terms of protein. Consequently, the Energy Ratio declined substantially from 0.46 to 0.35, while the energy to produce a kilogram of protein rose from 251 to 315 MJ.

But the most notable changes were in the substitution of energy for manpower. By 1972 each full-time farm worker was backed by a direct energy input of 502 GJ or 11.6 tons of oil equivalent per year. Counting all part-time workers, directors and the like reduces this to about 180 GJ per man year. Even this lower figure puts agriculture, on this measure, well into the category of heavy industries - in the UK the direct energy per man-year is about 130-140 GJ in engineering and 310 GJ in motor vehicle production. Equally significant, the marginal energy cost of replacing labor appears to have soared. In the early stages of farm mechanization it often took only 10-20 MJ of energy to save one hour of labor, but by 1965-70 this quantity had risen to around 230 MJ. According to S. S. and C. E. Steinhart (Science, Vol. 184, 1974, pp. 307-16) the equivalent figure for the USA during the same period was about 720 MJ per man hour saved (this is not corrected for higher food outputs per hour).

The overall food system. In a developed urban society such as the UK, farming accounts for only a fraction of the total energy required for food supply. Food has to be transported, processed, packed, stored and sold in shops, and in the UK it has to be imported in large quantities. The energy flow for the whole UK food system to the shop door for 1968 is estimated to be nearly 1300 million GJ, for a population of 55 million, or 15.7% of national energy consumption. The per capita consumption of 23.6 GJ is almost identical to an estimate of 23.7 GJ made by Hirst for the USA in 1963, when the food system accounted for 12% of the national energy budget. The Energy Ratios were also much the same at about 0.2 (see Table 1).

Nor is this a viable system for all people for all time. Copied on a global scale it would demand prodigious quantities of energy – 4000 million people each consuming 23.6 GJ per year of fossil fuels in order to eat (let alone cook) gives an annual fuel bill of 2185 million ton oil equivalent or 40% of global commercial fuel consumption in 1972. This figure might be reasonable if other efficiencies were especially high. We have already seen that they are not for labor usage, nor are they for land. Table 3, which summarizes the energetics of the UK food system, shows that the overall biological energy efficiency is only 0.02% while food outputs are, at most, 10.6 GJ per hectare, or only 6.7 GJ per hectare counting rough grazing. Each Briton depends on at least 0.71 hectare for food – ignoring all imports of food and feedstuffs. This is little less than the global average of 1.1 hectare per person counting crop land, permanent meadows and pastures.

Why are these efficiencies so low? The overwhelming reason is the high proportion of animal products in the diet and in farm outputs. The UK farm produces exactly equal amounts of dietary energy in the form of animal products and of crops fed directly to man (see Table 3). Yet while the latter are grown on 1.55 million hectares, animal production requires 10.25 million hectares of crops and grassland and approximately 1.52 million hectares for imported feedstuffs. Thus the crop sector is seven to eight times more efficient in its use of land to provide food energy than is the animal sector. This is a minimum estimate since it ignores a further 6.65 million UK hectares of rough grazing suitable only for animal raising.

The Global Challenge

In the underdeveloped world the imperatives of agricultural development are to increase food yields, quality and reliability – and hence the wealth of agricultural communities – without high costs, severe environmental impacts or reduced employment. Carbon copies of Western methods are mostly irrelevant or at worst dangerous. New strategies are needed, and in these energy plays a peculiarly important role.

Consider Table 4 which shows how energy is supplied to six "prototypical" villages in the Third World. These are farming

Table 3. Summary of energetics of UK food system, ca. 1968

	Biological flows			10^6 GJ per year
A.	Solar radiation incidence			610 000
B.	Primary production harvested from plants			1 116
C.	Imports of animal feed			104
D.	Edible farm output: crops		65	
	animals		65	
E.	Total edible farm output			130
F.	Food energy consumed by population			261
G.	Primary conversion efficiency (B/A)	0·18%		
H.	System efficiency [E/(B+C)]	10·7%		
I.	Overall efficiency (G x H)	0·02%		
J.	Food energy self-sufficiency (E/F)	50%		
K.	Food protein self-sufficiency	62%		
L.	Food energy output/ha of crops and grass in UK			10·6
M.	L including rough grazing			6·7
	Industrial energy flows			
N.	Energy input to agriculture (and % all UK)	4·6%		378
O.	Energy input to food system (and % all UK)	15·7%		1 300
P.	O counting home-related energy use	(22%)		1 820
Q.	Energy ratio of agriculture (E/N)	0·34		
R.	Energy ratio for whole food system (F/O)	0·20		
S.	R including home-related energy (F/P)	0·14		
				GJ per year
T.	Energy input (O) on *per capita* basis			23·6
U.	Agricultural input/ha for crops and grass in UK			30·7
V.	U including rough grazing			19·5

communities. Almost all the human and animal energy is used in food production, including irrigation, and much of the wood, dung and crop wastes are used for cooking. Several striking points emerge:

1) When cooking is included, energy used in the food system is comparable to that in the West. With these fuels, per capita annual consumption for cooking is about 5-7 GJ compared to 1-2 GJ for modern gas stoves and three GJ for electric stoves in the USA.

2) The cooking fuels are precious resources - dung as fertilizer, crop wastes as manures or animal feeds, and wood as ecological capital. Growing pressures on fuelwood throughout much of the Third World, where annual consumption is often 1-1.5 tons per person per year, is creating ecological threats through indiscriminate tree felling with subsequent erosion and creation of deserts.

3) Energy supply is overwhelmingly from food or biological sources (the Mexican village excepted) with extremely low efficiencies of use. With draught animals the conversion of fuel to useful work is about 3-5% compared to 25-30% for a tractor. Similarly the conversion of fuels to useful heat in cooking is about 5% compared to 20-25% in a modern gas or electric stove.

Table 4. Energy use in six Third World villages

Village	Gross energy (GJ *per capita*)				
	Wood, dung, crop wastes	Commercial fuels	Human labour	Draught animals	Total
Mangaon, India	4·2	0·2	3·2	7·9	15·5
Peipan, China	21·1	3·6	3·2	5·3	33·2
Kilombeo, Tanzania	23·2	—	3·2	—	26·4
Batagawara, Nigeria	15·7	0·05	3·0	0·75	19·5
Quebrada, Bolivia	35·4	—	3·5	10·6	49·5
Arango, Mexico	15·1	38·9	3·8	7·6	65·4

Source: A. Makhijani (see next article) converted from million Btu to GJ units.

In all such communities, adequate power to work the fields and to pump irrigation water (where available) is crucially important for raising yields and avoiding the ravages of drought - and hence for increasing the wellbeing of people. Normally this power is not available because the efficiencies of using energy are so low and the total available energy is limited. Apart from the costly solution of providing more energy from outside by commercial fuels and electrification, the single most urgent need in the food-energy equation is to find cheap ways of harnessing more effectively the energy that is locally available, i. e., using it with higher efficiencies. This in turn means providing storable energy with high thermodynamic value - for example, gas or liquid hydrocarbons rather than dung, wood and vegetation.

It is becoming increasingly obvious that bioconversion and the direct use of solar power provide the way out of this trap. The skills and technologies are simple, and the fuel sources are widely available, forever renewable (with care) and ecologically inoffensive (with care). Perhaps above all, they are ideally suited to small-scale, self-help, decentralized development which is so relevant to the great majority of the world's poor who still live in scattered rural communities. Consider what the conversion of organic matter to biogas (approximately 60% methane) would mean in general terms for such villages [described in the next article].

A similar argument applies to other renewable energy sources which provide concentrated fuels or power. These include liquid fuels obtainable from plant matter by fermentation, destructive distillation or pyrolysis for powering machines such as cultivators or small tractors; electricity from biogas or 'fuel forests'; conventional solar panels to provide hot water and space heating in colder mountain regions; and simpler versions of solar-electric devices such as that proposed by the Meinels of Arizona University for concentrating sunlight onto pipes, storing the energy in molten salts or rocks, and extracting it as required (day or night) to drive turbines to provide electricity at overall conversion efficiencies as high as 25%.

The development and diffusion of energy devices of these kinds throughout the rural areas of the Third World is an enormous challenge. Perhaps above all the challenge is to the broadness and subtlety of our vision. Many of these devices have been costed by the conventional calculus of economics and have been found either to be wanting or only marginally attractive compared to more conventional technologies. The question is whether the conventional calculus, with its high rate of discounting the future and its failure to catch many of the most relevant factors in its net, is the most appropriate guide. No one has yet thoroughly explored the multitude of consequences and transformations that developments of this kind could bring about - not least on food production, on rural incomes, on personal wellbeing and self-respect, on the invigoration of village life, and on the mass migrations to the exploding cities of the Third World - in short, on the whole development process.

[Extracted from Food Policy,
Vol. 1, No. 1, November 1975,
pp. 62-73. IPC Science and
Technology Press Ltd., Guilford,
Surrey, England; Copyright ©,
IPC Business Press Ltd., 1975.]

Fuel for Agriculture in the Third World

Arjun Makhijani

[A basic need for the growth of Third World agriculture may be supplied by the use of crop residues and manure to make methane gas for fuel in small village biogas plants. This article examines the economics of such plants under current conditions in an Indian village, which appear favorable, and describes the great potential for this technology in agricultural development.]

Poor countries need all the energy they can get, as cheaply as they can get it. Development policy in most underdeveloped countries has bypassed the effective use of noncommercial fuels from energy sources other than oil or coal, partly because cheap oil was available but also because technology has been borrowed from the industrialized countries which have failed to develop and tap these sources of energy. We wish to explore alternative technologies and to examine, in view of the large increases in the prices of oil and fertilizers in 1973 and 1974, the economics of decentralized energy systems in providing fuel and electricity to Third World villages from locally available sources.

Among the decentralized technologies, we have devoted the most attention to the conversion of organic materials to gas in village biogas plants because it appears to be an economical way to provide fuel and fertilizers for Third World villages with a great, but so far almost untapped, potential. The basic raw materials for producing fuel and fertilizer in biogas plants, i. e., crop residues, increase as agriculture becomes more productive. In fact,

Mr. Makhijani is with the Foundation
for Research in Community Health,
Kaloba District, Maharashtra, India.

the agricultural sector has the potential of taking care of its own energy needs and having some left over for domestic uses, transport, or other uses.

Electric power from fossil fuels. The usual way of supplying electric power for rural places is to generate electricity in a large central plant and send it through an extensive transmission network to a wide area. The cost of electricity in the village, from large-scale oil or coal-fired thermal electric generating plants, is the standard against which alternatives are usually measured. It will be the measure here.

Two important values must be established before realistic choices for development can be made. These are the capacity factor and the interest rate for invested capital. "Capacity factor" is the proportion of a power plant's capacity which is actually in use, on the average, over a period of time. The capacity factor in villages is very low. In India, the average annual rural capacity factor is about 10 percent (800 kwh/kw). This compares with the 40 percent which is characteristic of urban demand in India and many other underdeveloped countries. The effect of such low capacity factors is to greatly amplify the capital cost per unit of electricity generated and to reduce the relative importance of variable costs. Capital-intensive power supply systems will therefore be at a disadvantage unless rapid development takes place simultaneously with electrification, and as power becomes available its use for such purposes as irrigation for multiple cropping rises in such a way as to increase the capacity factor.

The interest rate for capital is also an important determining factor in the choice of the technology to be used. A commonly accepted rule of thumb is 12 percent; this figure does not include depreciation or inflation. While this interest rate is higher than rates that are sometimes used to justify development projects or capital-intensive schemes, we use it to give appropriate weight to the shortage of capital prevalent in most underdeveloped countries.

Table 1 shows the capital and other costs of generating electricity in central power stations and distributing it to rural places, using coal-fired generating plants. Using India as an example, several critical factors determine whether centralized or decentralized generation is more economical: the capacity of the distribution system, the capacity factor, and the distance of the village from a main transmission line. The cost of electricity delivered to a typical electrified village (that is, a large village) in India is around 8 to 10¢ per kwh. This is much higher than the 2¢ per kwh or so actually charged rural customers in India because only the cost of the distribution system is included in calculating what the charge should be. Thus the users of electricity in Indian villages are receiving a continuing large subsidy from the government.

Table 1. Cost of Centralized Electricity Supply in Coal-Fired Generating Plants in India (U. S. Dollar equivalents)

Capital cost of central fossil fuel generating station per kw	250	
Transmission cost per kw (20% attributed to rural line)	50[a]	
Rural distribution cost if village is 8 km[b] from line, $25/km/kw	200	
Total capital cost per kw	500	
Annual interest and depreciation per kw, 15%	75	
	15% capacity factor	10% capacity factor
Interest and depreciation per kwh	6.5¢kwh	9.4¢kwh
Approximate fuel and maintenance cost per kwh	1¢ kwh	1¢ kwh
Total cost	7.5¢kwh	10.4¢kwh[b]

[a] Assuming that a 100 kw powerline goes to the village.

[b] At 16 km from the transmission line the total cost becomes 14¢/kwh; at 24 km it becomes 18¢/kwh.

It is almost impossible to generalize accurately about the cost of electricity generated in small village diesel sets. Installation and fuel costs will vary from village to village. On the whole it appears that electricity from decentralized small-scale diesel generators is more expensive than power from central stations if the village is reasonably large (more than a few hundred people) and less than about 10 km from a high-tension transmission line. Figures corresponding to the 7.5 - 10.4¢ per kwh range in Table 1 would be 11 - 13¢ per kwh.

Biological materials as an energy source. Biological materials are the most important immediately viable decentralized energy source for electric power and for mechanical power as well. They can be used directly as fuel or converted to other forms. The economics and technology of using wood and agricultural wastes directly to raise steam for power production are not very favorable. Capital costs are high and the efficiencies of small plants are low (10 percent). Steam engine generating plants with a capacity of a few hundred kilowatts cost $600 to $800 per kw. Given the low capacity factors encountered in rural areas, electricity costs of 10¢ to 20¢ per kwh may be expected even if we ignore fuel costs.

The destructive distillation of wood in the absence of air (pyrolysis) is an ancient technology which may be an economic approach to providing fuel for small towns, though not for most villages, since the plants required are too large and the costs of pyrolysis are sensitive to the size of the system. Pyrolysis of wood (or other organic matter such as newspapers and food wastes) produces charcoal, a medium Btu gas (10,000 to 18,000 Btu per cubic meter compared to about 36,000 Btu for natural gas) and combustible liquids with around 70 percent efficiency. We are not aware of any recent attempts to evaluate this old technology for use in poor countries in view of current high oil prices. However, there are a few indications that the economics of wood pyrolysis might be attractive. First, wood is currently used in China as a tractor fuel,and was used even when prices of oil were low. Second, wood pyrolysis was phased out in the industrialized countries because of cheap oil and the relatively high cost of labor (associated primarily with the collection and transportation of wood). Neither of these conditions applies today to poor countries.

Biogasification is perhaps the most important technology for converting biological material to more useful forms of fuel. It can be put to widespread use in the near future, its economics appear favorable, and it produces organic fertilizers in addition to fuel. In this process complex biological materials are broken down by anaerobic bacteria (that is, bacteria that work in the absence of atmospheric oxygen) to simple organic compounds which are in turn converted to methane and carbon dioxide. Of the biological materials encountered in nature, only mature wood appears to be largely resistant to breakdown; the plant material and manure that comprise most agricultural residues are broken down.

A biogas plant consists of digestors (the receptacles in which the biogasification takes place), facilities for storing and slurrying the residues, and sometimes facilities for grinding the residues and drying the residuum from the digestor. A system large enough to supply a village reliably should include two or three digestors and gas storage. The digestors produce an intermediate Btu gas (20,000 Btu/cu. m.) consisting primarily of methane (55 to 65 percent by volume) and carbon dioxide. Standard techniques for the removal of carbon dioxide and small amounts of hydrogen sulfide can produce methane, a high Btu gas similar to pipeline quality natural gas. (The Monfort Company, in Greeley, Colorado, U.S., plans to build a large biogas plant on its cattle feedlot and sell the purified gas to a natural gas pipeline company.

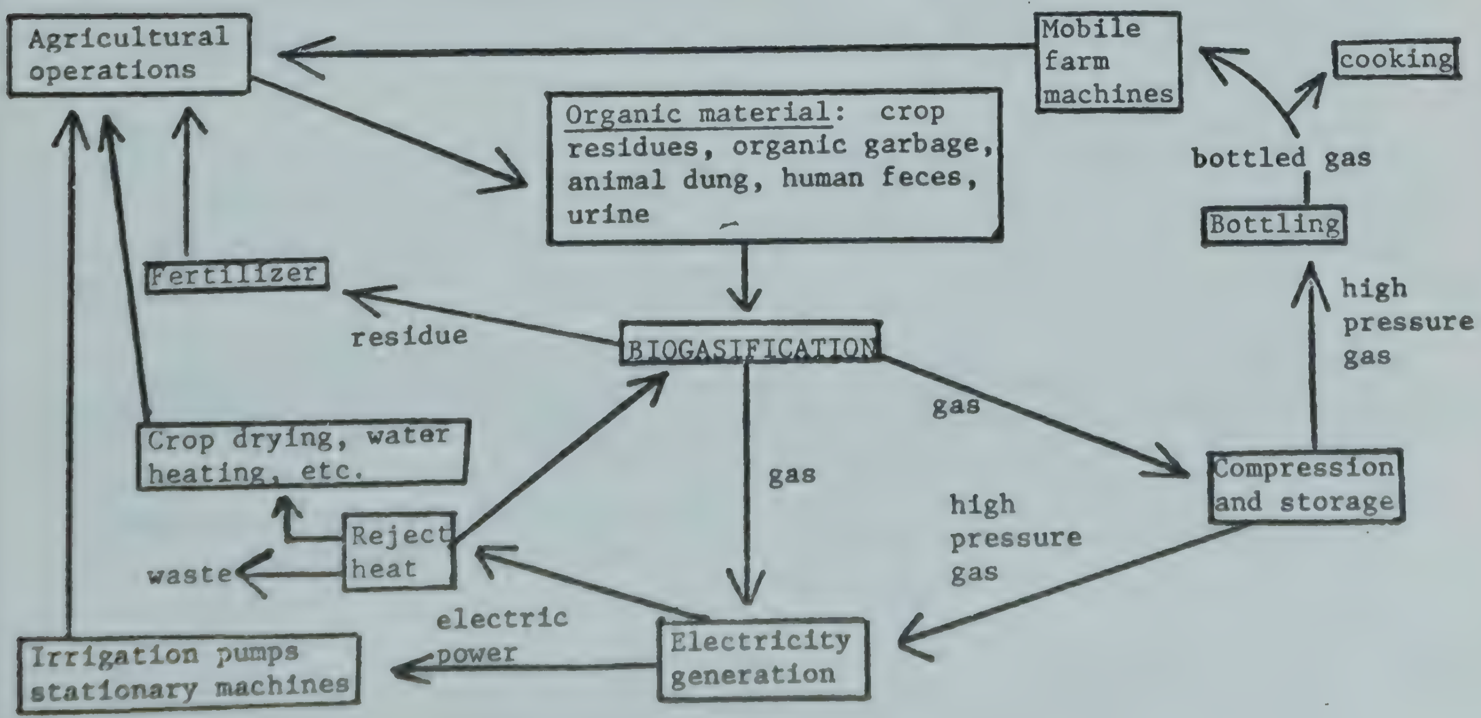
From the point of view of returning nutrients contained in biological materials to the soil, biogasification has an advantage over ploughing in manure since the fertilizer is already in usable form, in contrast to manure which must usually be allowed to decompose in the soil for many days before planting. This is especially important with multiple cropping, since prompt planting permits more crops.

The use of biogas as a basic energy resource for villages had been recommended by the Fuel Policy Committee of India and it is now the object of special study of the National Academy of Sciences of the U. S. as a promising source for supplying energy to villages in the near future. Much of the work on the development of small biogas plants has been done in India, and since 1973 there has been a resurgence of interest in applying this technology to meet some of India's fuel and fertilizer problems. Several thousand small biogas plants have been built on individual farms. Currently, most of this gas is used for cooking rather than for agriculture. The basic resource - agricultural residue - is found wherever there are agricultural communities. The technology for converting these residues is also well enough understood for us to make a preliminary economic evaluation and a comparison of the costs of village electrification schemes based on biogas with those based on central station generation.

A possible rather advanced village scheme is outlined in Figure 1. An important feature of this scheme is that farmers are paid for the residues which they deliver. The price paid for the residues will vary from region to region depending largely on the ease of collecting the residue, the suitability of the residue for gasification,

---

Figure 1. Schematic Diagram of Village Biogas-Electricity Scheme System


Agricultural operations
Mobile farm machines
cooking
Organic material: crop residues, organic garbage, animal dung, human feces, urine
bottled gas
Bottling
Fertilizer
high pressure gas
residue
BIOGASIFICATION
gas
Crop drying, water heating, etc.
gas
Compression and storage
Reject heat
high pressure gas
waste
electric power
Irrigation pumps stationary machines
Electricity generation

and whether the wastes are currently used for other purposes such as cooking. Prices might vary from about 70¢ per million Btu of animal manure in North Indian villages where dried manure is used for cooking fuel and is scarce, to 20¢ per million Btu for crop residues or dung where these are abundant and are not presently used.

Paying for raw fuel on the basis of energy content will favor the delivery of crop residues, for they have a much higher energy value per ton than wet manure which, in its fresh state, has a water content of up to 80 percent. This has an important advantage but may also create a problem which must receive simultaneous attention. The advantage is that it is more efficient to gasify crop residues directly rather than feeding them to animals. But if sales of crop residues deprive cattle of their fodder, the result could be a reduction in the number of cattle (which may or may not be desirable), or still feebler cattle, or more overgrazing of pastures. The price for the fuel for the biogas plant should ordinarily be based upon the prevailing wage rate and the fuel and fertilizer value of the material; but it may have to be modified and varied from one year to the next depending on the availability of crop residues to take account of the important indirect effects on the village economy.

The gas the plants produce which is not used immediately for electricity would be compressed and stored. Bottled gas would provide the fuel for farm machines and, if necessary, for cooking. The compressed gas could be taken from storage and used when needed at times of peak demand for irrigation pumping, tractors, etc. Such a fuel is obtained economically at consistent high capacity factors. Compressed gas storage is relatively inexpensive in both economic and energy terms. The large amount of waste head produced in the generating plant (about 75 percent of the total input) would be relatively high grade heat with a temperature of about 300°C. Part of this heat could be used to regulate the digestor temperature. The rest could be used for crop drying, producing raw sugar, heating water for domestic uses, and so on.

The residuum of undigested materials which leaves the digestor is an excellent organic fertilizer. It could be returned to the land either mixed in the irrigation water or as a semi-solid, after dewatering. In some places such as North India and Tanzania, this return of nutrients would mean a large increase from present use of fertilizer. In others where composting and manure are already used, such as China and South India, it would reduce the organic fertilizer losses inherent in composting; but the principal benefit from biogasification would be the fuel produced. Digestor residuum does not attract flies which spread many diseases, and digestion at the right temperatures also suppresses the pathogens in human feces.

The safe disposal of human excrement (feces and urine) is one of the most important measures for the prevention of disease in Third World villages. The pathogens that human excrement harbors cause a variety of serious diseases such as cholera, typhoid, schistosomiasis, amoebic dysentery, and enteritis. These pathogens can be destroyed by uniform heating to 60°C for 30 minutes to one hour. In anaerobic digestors that operate in the intermediate temperature range 25°C to 40°C, the pathogens may take several weeks to be destroyed. However, organisms may well be completely destroyed in the 40° to 60°C range which would apply to properly managed compost piles, or to anaerobic digestors appropriately heated, for example, with waste heat from a biogas-electricity generating plant. The amount of heat required would be about equal to the amount of gas generated from the feces. There would be no net gain in fuel from processing the human excrement; the gains would be in improved health and in the output of fertilizer. Composting of excrement, which may be cheaper but more difficult to manage, would achieve the same result. Apart from the significant health benefits, large quantities of fertilizers, particularly fixed nitrogen, can be recovered from human excrement (particularly urine which has a high nitrogen content). Building latrines could be a profitable proposition on the basis of the value of the recovered fertilizer. Some approximate calculations for the costs and value of output in such a scheme were made for Indian villages by the Khadi Village Industries Commission. If the operation is conducted on a nonprofit basis, an annual payment could be made to each family for using the latrines.

Decentralized energy systems have often been dismissed on the grounds that maintenance would be difficult. Electricity use in Indian villages tends to decline over time, even when the electricity comes from a centralized source, which points to a lack of local maintenance. Much of the capital investment for agricultural development must be made in the villages, in tubewells, pumps, motors, irrigation channels, and so on, whatever the source of fertilizers or power. If these facilities are not maintained, then no program can achieve the goal of agricultural progress. But, if the personnel to service these essentially decentralized aspects of agricultural development are trained and available, then the added problems of biogas plants and decentralized electricity generation should not be difficult.

Energy availability for biogas. To estimate the energy from wastes available for power generation, we must know the energy content of the basic resource - the agricultural residues. Accurate estimates would require the following information: (a) a breakdown of crop production in individual villages; (b) the agricultural residues associated with each ton of harvested crop; (c) the amount of crop residues consumed by animals; (d) statistics for the animal population, including both numbers of animals of each type and the average weight of these animals; (e) data relating to manure production and its quality with due regard to feeding conditions normally encountered in villages, and the ease of collection of the manure. None of this information is available in any general and authoritative form. We have attempted preliminary estimates of the available energy residues in six selected villages in India, China, Tanzania, Nigeria, Mexico and Bolivia which are representative of many agricultural systems in the Third World.

Estimates of the "residue coefficients," that is, the ratio of the weight of dry matter residue to recorded harvested weight at field moisture, have been computed for important crops by the U. S. Department of Agriculture and others. For most crops they fall between 1. 0 and 2. 0; for some they may be as high as 3. 0 (cotton, soybeans), and for others less than 1. 0 (sorghum, sugar cane); they vary considerably with plant varieties and harvesting practices. In the six representative villages, the annual averages for harvested crops, the volume of dry crop residues, and the energy content of the latter were estimated for each village. Counting crop residues not eaten by the animals present in these villages, and assuming that 80 percent of this mass is collectable for use, the quantities range from 700 up to 27,000 tons per year. Similarly, annual kilograms of manure production from the cattle, horses or donkeys, pigs, sheep and goats, or poultry were estimated for each village. Nitrogen content was estimated, assuming levels from 1 to 2 percent for most animals but 6. 3 percent for poultry, and assuming 70-80 percent manure collection (30 percent for sheep and goats). If these residues and manures were converted to biogas at 60 percent efficiency, the village totals for energy production have a wide range from 500 to 13,000 million Btus per year - the largest for the Mexican village which has extensive irrigation and large crop residues. Dividing by number of inhabitants, we find energy availability from this method is 3-4 million Btus per capita average a year in three villages, with 5, 8, and 30 million in the others. If the fertilizer residue from biogasification were used in agriculture, it would supply nitrogen at rates of 18, 20, 25, 33, 65 and 68 kilograms per cultivated hectare. [Supporting tables for these calculations are found in the original book.]

In all cases, the existing energy use for irrigation and farm machines in these villages is lower than the potential available from biogas. As for fertilizers, except in two cases the potential quantities are several times the amounts of nitrogen fertilizers that are now used. For the development of agriculture in such villages, however, it will be necessary to think in terms of increasing productivity by use of improved seed varieties and multiple cropping, which will greatly increase the need for fertilizer. The available nitrogen fertilizer from manure varies a good deal and is often not sufficient to allow the use of high-yielding seed varieties. Other sources of nitrogen would be necessary, and phosphorous, potassium, and other trace minerals must usually be purchased. Fortunately, these mineral fertilizers are less expensive than chemical nitrogen; unit prices are lower, and the amounts needed are usually less. Planting several crops each year will certainly require the use of chemical nitrogen, although the animals supported by crops could be increased.

Cost of a biogas-electricity system in the village of Mangaon, Bihar, India. We now compare the costs of a biogas-electricity system under conditions in the Indian village of Mangaon with the costs of conventional rural electrification projects in India which are based on centralized electricity generation. In comparing these costs, one should take into account as a deduction from cost the value of gas for cooking and of the fertilizer returned from the system to the land. In Mangaon this nutrient value is now lost, as virtually all collected manure is burned as fuel. We have assigned a value of $400 per ton of nitrogen content. This is a conservative value, above the $300 government price of urea in 1973 but well below official prices of over $500 in 1974 and the still higher prices paid by farmers to intermediaries. Gas used for cooking fuel is valued at $2.00 per million Btu.

Table 2 shows the capital costs for two biogas-electricity schemes, one with provision for supplying gas for cooking, the other without. The cost shown in column A indicates that if half the biogas produced is used for cooking, the capital costs of the electric power from biogas is only slightly less than that for a centralized scheme (assuming a main transmission line 8 kilometers from Mangaon). This is not only because of the costs of distributing and using cooking fuel but, more importantly, because only half of the gas produced can be used to generate electricity. The capital cost per kilowatt of the biogas-electricity scheme with no gas for cooking (column B) is about half that of the centralized scheme.

The annual costs of the two schemes are shown in columns A and B of Table 3. With the conservative assumptions that are used in calculating these costs, the cost of electricity produced in the scheme in which biogas would be distributed as cooking fuel is slightly higher than the cost of the centralized scheme shown in Table 1. For the second case the cost of electricity would be considerably lower: 5.8¢ per kwh compared to 7.5¢ per kwh or more. One of the conclusions to be drawn from Table 3 is that, contrary to current practice, biogas should not be used for cooking unless it is necessary.

Table 2. Capital Costs of Biogasification-Electrification System in Mangaon (in 1974 Dollars)

	With 50% Cooking Fuel A	Without Cooking Fuel B
Biogasification plant[a]	8,000	8,000
Gas plant auxiliaries	1,000	1,000
Land cost	1,000	1,000
Gas storage and compression[b]	1,500	1,500
Cooking fuel distribution cylinders and gas stoves[c]	8,000	—
Electric generator with reciprocating gas engine and switchgear at $160/kw installed[d]	12,000	22,500
Construction supervision and training	1,000	1,000
Subtotal: capital	32,500	35,000
Interest on capital during six months' construction at 12%	2,000	2,000
Total	34,500	37,000
Cost per kw	$460	$265

[a] We assume two digestors, each producing 140 cubic meters of biogas per day. The gas production in columns A and B is the same. Exclusive of the energy use in the biogas plant, the digestors will produce about 2 billion Btu of fuel per year.

[b] Storage for 50 percent of annual production of unscrubbed gas.

[c] Column A assumes all 200 families in the village use methane for cooking, $6,000 for cylinders, $2,000 for stoves. Column B assumes zero use.

[d] Based on mid-1974 quotation from a manufacturer in the U. S. A. and includes approximate shipping costs. In the scheme with cooking fuel we have a 75 kw generator (col. A); without cooking fuel the entire output of the gas plant goes to a 140 kw generator.

Table 3. Annual Costs for Two Biogas-Electricity Schemes for Mangaon, India (in 1974 Dollars)

	A With Biogas for Cooking Fuel (50%)	B No Cooking Fuel Provision
1. Annual interest and depreciation[a]	5,700	6,100
2. Residue collection at $2/ton fresh manure	2,600	2,600
3. Local labor and maintenance[b]	1,300	1,300
4. Market town services	500	500
5. Labor for distributing cooking fuel[c]	300	—
6. Gross annual costs	10,400	10,500
7. Credit for cooking fuel sales[d]	-2,000	—
8. Credit for fertilizer[e]	-2,400	-2,400
9. Total credits	-4,400	-2,400
10. Net annual operating cost	6,000	8,100
11. Annual electricity generation at 12.5% capacity factor	75,000 kwh	140,000 kwh
12. Cost per kwh	8.0¢	5.8¢

---

[a] Interest rate 12 percent. Biogas plant (digestors) depreciated at 3 percent per year, other capital at 5 percent per year.

[b] About one man-year, plus parts.

[c] One man-year for distributing gas.

[d] Charge for biogas used for cooking $2.00 per million Btu.

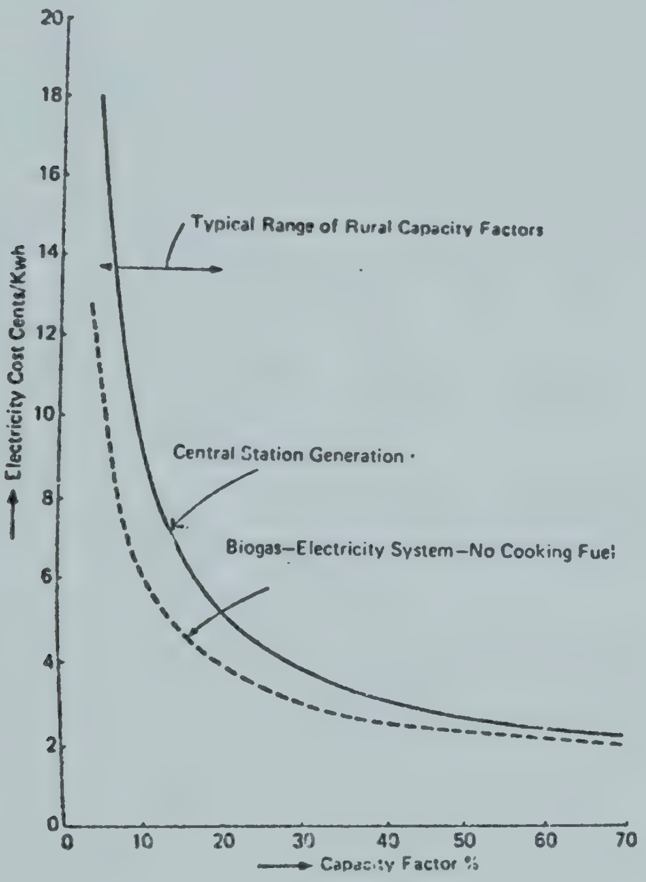
[e] Credit taken only for fertilizers available in the solid portion of collected dung - four tons of nitrogen at $400 per ton, two tons of phosphorous (P_2O_5) at $250 per ton, and two tons of potassium (K_2O) at $150 per ton.

The cost of manure collection in Table 3 is high because it is assumed that only animal dung is used in the biogas plant. Crop residues contain about five times as much energy per ton as wet dung, so that the cost per million Btu of input to the digestor, and hence the cost of electricity, would be lowered as more crop residues are used (that is, as more food is grown and surplus crop residues become available). The net cost of electricity depends critically on the value of the fertilizer content of the residuum in the biogas digestors. In Table 3 we have assumed that only the nitrogen in the solid portion of the dung is available. This gives an annual production of four tons of nitrogen, two tons of phosphorous (P_2O_5), and two tons of potassium (K_2O). Proper preparation of household stables (or common stables) with straw, sawdust, and other cellulose litter will absorb the urine. This would increase the nitrogen available to seven tons per year, with smaller increases in phosphorous and potassium. The nitrogen can be further increased to 10 tons of nitrogen per year if latrines for collecting human excrement are installed and widely used. When animal urine is included, the cost of electricity in both cases is lower than that of the centralized system. The costs of electricity and biogas are lowest when human excrement is also used: they could be reduced to 5.3¢ per kwh in column A and 4.4¢ per kwh in column B.

Introduction of electricity. The foregoing discussion of costs is based entirely on current patterns of electricity use. These are wasteful of capital. Rapid development will require that capital be used much more effectively than it has been previously, the more so for countries that are hard pressed to pay for food, fertilizer, and oil imports. In India, rural electrification and irrigation account for almost all the government's rural capital investment. If the cost of these programs is to be reduced so they can be offered to more people, it is imperative to improve the capacity factors as this will make electricity cheaper from whatever source, central or local, and from whatever fuel. Figure 2 which shows a graph of electricity cost versus capacity factor illustrates this principle, and shows the enormous reduction in electricity cost achieved when improvement of only a few percent is made in the prevalent low capacity factors.

In most cases it would be preferable to delay the introduction of electricity until a sufficient capacity for its use has been built up. Irrigation pumps and farm machines could be powered by internal combustion engines (the same ones for both purposes so far as possible). This would reduce the capital cost of providing energy for agriculture considerably, and current costs per unit of useful energy obtained directly from an internal combustion engine are much lower than the corresponding costs for electricity because the intermediate generating step is eliminated. As small industries in the village develop, electricity could be introduced.

Figure 2. Variation of Electricity Cost with Capacity Factor



Electricity is desirable for irrigation and for powering stationary small machines because electric motors are more reliable and need much less maintenance than internal combustion engines. After electricity is introduced, the internal combustion engines could be used for transporting produce to market towns as well as for some stationary applications such as sugarcane crushing. Electrification is also important for the positive psychological effect it has on people's attitudes, for establishing a modest communications system, and so on. From an energy point of view, using local energy resources to generate electricity has advantages both over centralized generation and over the use of fuels in many dispersed internal combustion engines. The waste heat, which is usually 300°C or higher, can be put to many beneficial uses, such as crop drying, local manufactures, or water heating. The greater the variety of uses for electricity (and waste heat), and the more evenly they can be distributed over the year, the higher will be the capacity factor and the lower the unit capital cost.

Fuel for farm machines. Even more than with rural electrification, a principal problem with supplying fuel for farm machines is not so much the price of oil relative to other sources but the foreign exchange shortage. Thus in Punjab, India, which supplies the country with most of its surplus wheat, many tractors and irrigation pumps lay idle in 1974 because farmers could not get enough oil. In relatively large villages (say, 500 or more people) where gas for cooking is not required, biogas would be a cheaper fuel than oil for fueling farm machines and small trucks or tractors with trailers. For example, a farm machine used 10 hours a day for 15 days will require about 10 million Btu of fuel, assuming an average power output of 5 horsepower. Diesel fuel delivered to the village will cost over 50¢ a gallon (about $4 per million Btu), and gasoline will be even more. Petroleum costs for such an operation are likely to be about $40, much of this in foreign exchange. Fuel from a biogas plant can be provided for $25 or less, including the cost of the gas containers and compression equipment. In villages smaller than 100 people, the costs of the compressors and other equipment needed to bottle the gas may make oil the cheaper alternative even at present high prices, particularly if there are only a few farm machines. The relative economics in such cases would also be affected by the location of the village since transporting oil to remote places is quite expensive. But if there are many small villages within a radius of 10 or 20 kilometers, biogas would probably be the cheaper alternative since common maintenance facilities could be provided.

In sum, the discussion of energy needs and the calculations presented here indicate that the fuel and fertilizer needs of villages and market towns in the Third World can best be met by a combination of the centralized and decentralized approaches, rather than by the centralized approach alone which has been used so far. The potential of rural sources of fuel and fertilizers in spurring agricultural growth seems great. Pilot projects are needed to determine more accurately the costs and problems of implementing such decentralized projects in different areas of the Third World.

Illustration of Growth Potential

As a specific illustration of the concepts presented above, we examine the potential for agricultural development under conditions in Mangaon, India. Because of its poverty, and the scarcity and low productivity of land in that region, the resource constraints are greater than they would be in most regions. The village population is 1,000. Annual production, on 282 cultivated hectares with some 300 draft animals, totals nearly 600 tons. Crops, in order of tonnage are: sugar cane, rice, maize, wheat and barley.

Mangaon as it is today - with its one crop per year, less than one ton per hectare economy - has a potential for agricultural production, labor and land productivity, and number of productive jobs that is immensely greater than in the past. Water resources are abundant; the land is fertile; there are plenty of fish in the rivers. To explore that potential, let us examine whether in theory (that is, institutional constraints aside) it is possible for Mangaon to grow enough food for its own people and export half of the food it produces. Let us define "enough food" as 2,500 kilocalories and 70 grams of protein per person per day. The results of our calculation should not be interpreted literally, for they are simplified and represent only one hypothetical example of what could be achieved within today's technical and economic constraints.

The principal constraints we consider, other than the fixed amount of agricultural land, are these:

1. No source of energy is available from outside the village. This is related to the foreign exchange shortage which limits oil imports, and to many diverse problems with India's coal industry.

2. No more than 15kg/ha of chemical nitrogen per year is available during the initial period of five years. This corresponds approximately to India's current capacity to produce chemical nitrogen.

3. The capital available for borrowing from outside the village is no more than $10 per year per person.

Because of the warm climate, fertile soil, and plentiful supply of water, three or more crops a year can be grown in Mangaon (except sugar cane, which takes a full year to mature). Recall that in the Hunan region of China, which is somewhat colder than Mangaon, growing three crops a year is commonplace. Growing three crops a year requires irrigation and fertilizers, and we assume it requires one horsepower per hectare of farm machines. Constraints on capital available from outside the village will limit the initial rate at which projects can be undertaken, assuming that, to begin with, there is no capital available in the village.

We assume that a loan of $10,000 per year ($10 per person) can be obtained at a 12 percent interest rate, to be paid back in husked grain at 30¢ per kg and that the first payment would be in the fifth or sixth year. Repayment of the principal and interest in the form of food effectively makes the investment inflation-proof, in an economy where prices are in large measure determined by food prices. It would also make it easier to pay for the labor invested in future development projects with food.

The cost of tubewell irrigation (excluding the cost of the engines and energy supply) is about $150 per hectare. (Throughout this illustration we have used the data of the Musahri Plan written by Ranjit Gupta as the basis for estimating capital costs and employment.) Farm machines would cost about $20 per hectare ($300 for a 15 horsepower tractor, manual starter). We assume that the engine of the farm machine would also provide the motive power for the irrigation system. If we add $20 per hectare primarily for drainage works (important in the Gangetic plain) and $10 per hectare for contingencies and other small but important investments such as food storage, we find that, excluding energy supply, $10,000 would irrigate and supply the farm machine requirements for about 50 hectares.

A biogas plant to convert dung and plant residues to methane and fertilizer with a capacity of 1,000 million Btu per year would cost about $10,000. Forty percent of the fuel would be used for cooking to replace the dung so used. We have used the estimates for the biogas plant with gas for cooking (column A, Table 3). No electricity would be generated in the initial period, and the gas would supply fuel for cooking (400 million Btu), for farm machines and irrigation pumps for 50 hectares (500-550 million Btu), and for operating the biogas plant and compressor and pumps (about 50 million Btu).

The biogas plant would also supply 3 tons of fixed nitrogen, 1 ton of phosphorous (P_2O_5), and 1 ton of potassium (K_2O) per year. If 10 kg of chemical nitrogen were available for each of the 300 hectares in Mangaon (that is, about equal to the current use), and if it were used only on the irrigated land, then the supply of nitrogen, organic plus chemical, would be about 120 kg/ha. The timing of the project should be such that the gas plant is completed before the tube-well comes on line. The total cost of this initial phase would be $21,000, or about two years' supply of capital. This would include $1,000 for the chemical nitrogen and the $20,000 in capital assets built during the period. The construction during this phase would employ about 40 people full time (270 days a year) for two years.

Let us assume that on the 50 irrigated hectares three crops of wheat, rice, and green beans are planted during the third year. A rice yield of 2,000 kg/ha (husked) - which is the average for Punjab, and much less than yields in Taiwan and Japan - would increase Mangaon's rice supply by 50 percent from 120 tons to about 180 tons. A wheat yield of 1,500 kg/ha, which is half of that often obtained in Punjab with high-yielding varieties, would increase the wheat supply by 300 percent from 25 tons to 100 tons. When combined with a bean yield of 1,000 kg/ha (dry weight), the total production would just about supply Mangaon's food needs as defined. In addition, the fuel value of the crop residues would be increased from 8×10^9 Btu to about 13×10^9 Btu. Just the extra fuel could supply Mangaon's agricultural energy needs for growing three crops a year on the 300 hectares. This initial phase would create at least 20 permanent jobs in agriculture.

Table 4. Investment and Output in a Multiple Cropping Scheme for Mangaon (in thousands of dollars per year)

Year[a]	Annual Loan[b] $	Total Increase in Annual Output[c] $	Locally Generated Annual Savings[d] $	Loan Repayment[e] $	Investment From Local Funds $
0	10	-	-	-	-
1	10	small	-	-	-
2	10	?	-	-	?
3	10	54	13	-	Food Storage[f]
4	-	81	20	10	10
5	-	108	27	17	10
6	-	135	34	24	10
7	-	162	40	30	10
8	-	189	47	9	38

[a] The number in the column designated "Year" denotes the number of years from the start of the project. For simplicity it is assumed that the entire capital investment is made at the beginning of the year.

[b] The total investment required per hectare is about $200. The annual loan is the capital borrowed from sources outside the village, initially assumed to be the only available development capital.

[c] It is assumed that three crops a year are grown - rice, wheat, and beans - and that the yields per hectare are 2000, 1500 and 1000 kg, respectively. The value of the produce is taken as 30¢/kg. Base yield, that is, yield before project implementation, is taken as 850 kg/ha.

[d] It is assumed that 25 percent of all the increases in production over the initial production is retained by the village cooperative for loan repayment and further capital investment.

[e] Interest is calculated at 12 percent per year on the unpaid balance.

[f] It is assumed that the savings in year 3 are used to build up emergency food stock.

If the next two years' capital were again used in the same fashion, Mangaon could export about 130 tons of grain (wheat and rice) and 50 tons of beans. At 30¢/kg this amounts to $54,000. The total increase in annual food production at the end of the fifth year would be about 360 tons - around $108,000. This is about twice the capital invested, including a 12 percent interest rate. From this point on, it should theoretically be possible not only to repay the loan but to finance additional development with locally generated savings. Table 4 shows these financial and production aspects of the scheme in more detail. Note that if 25 percent of the production is retained by the village cooperative to pay back the loan and invest in further development, capital from outside the village is required for only four years.

This illustration is, of course, highly simplified. The pattern of investments would change as development proceeds. The investments made in electricity generation, roads, food storage, domestic water supply, fisheries, animal husbandry, marketing surplus food, and so on, would increase while investments in cooking fuel distribution and irrigation pumps would decrease. As their food needs are fulfilled, people would spend larger and larger portions of their increased income on other essential goods such as better housing or bicycles. This would create additional economic growth and provide for more employment. We have stressed that capital equipment be used as fully as possible so as to augment the investments for small-scale industries or other improvements such as health services.

Accomplishment of this kind is not possible with the present compartmentalized way of doing things, for it requires careful phasing and sustained, cooperative efforts. Achieving such progress is hardly likely to be as fast as we have depicted. But the calculations illustrate that the potential is there for the people of the Gangetic plain to participate fully and fruitfully in economic development, and that this potential can be realized within the rather stringent constraints on capital that exist in India.

[Extracted from Energy and Agriculture in the Third World, Ch. 4, pp. 95-130. Report prepared for the Ford Foundation by Arjun Makhijani with the collaboration of Alan Poole. Cambridge, Mass.: Ballinger Publishing Co., 1975. Copyright ©, The Ford Foundation. Any use of this text, in English or translation, is prohibited without permission from The Ford Foundation and Ballinger Publishing Co.]

FOREIGN INVESTMENT

A UNION CARBIDE CHEMICAL PLANT
IN BOMBAY, INDIA
(PHOTO: UNION CARBIDE)

Host Countries and Multi-National Corporations

Dale R. Weigel

[Developing countries are pressing hard for a foreign direct investment package that maximizes benefits to the local economy. Tax incentives are disappearing, fade-out regulations are increasing, and joint ventures are becoming more attractive to developing countries.]

It is difficult to imagine a subject that generates more controversy than foreign direct investment by multinational corporations in developing countries. Different observers, sometimes starting with different ideological points of view and often with different sets of facts, have arrived at different conclusions concerning the effect of direct investment by these corporations on the economic development of less developed countries. The purpose of this article is to discuss some of the controversies that have arisen in the hope that some common ground can be identified.

To be classified as multinational, corporations must control production facilities in more than one country. Firms that participate in international business solely by exporting or by licensing technology are not multinational. (Raymond Vernon, limiting the adjective "multinational" to firms that control operations in at least six countries, found 187 U. S. firms that fitted this definition.) Control of a foreign operation may stem from majority ownership of the foreign firm's equity; however, effective control is frequently exercised with less than majority ownership, especially if the equity is widely spread. Con-

Mr. Weigel is an economist in the Office of the Economic Adviser, International Finance Corporation, World Bank Group.

trol may also be maintained by contractual means as with a management contract.

The investments by multinational firms have been an important source of capital for developing countries. During the five years 1968-72 they received $3. 5 billion a year, over 20 percent of their total capital imports, through private direct investment. This is about half as much capital as they received from official development assistance. However, the developing countries as a group have been losing ground to the developed countries as recipients of direct investment. Data for U. S. firms (which accounted for one half of direct investment in developing countries in 1967) show that the proportion of their direct investments in developing areas fell from 42 percent of their total foreign assets in 1957 to 28 percent in 1972.

Monopolistic Advantages

Of course, it is not surprising that foreign investors are attracted most strongly to developed countries. These are the countries where markets are largest and, in many cases, growing more rapidly. So why do foreigners invest at all in the poor countries? In many instances, there are the particular advantages of raw materials and cheap labor to exploit for export production. However, in considering production for the local market, the motives for foreign investment are less clear. Foreign investors must expect higher profits from investing in the developing countries than could be obtained from the available alternatives, but this does not explain why direct investment is larger in some industries than in others, or why some firms invest while others in the same industry do not.

One answer that has come from extensive research in the last ten years is that direct investments in manufacturing industries are made by firms with some kind of monopolistic advantage that is best exploited by maintaining management control of operations in foreign countries. The advantage may be a superior product or production process; lower costs owing to economies of scale or preferential access to capital or raw material; or a product that the foreign company can, through advertising, differentiate from more or less identical local competitors. Some such advantage is a necessary condition of foreign direct investment if the foreign firm is to meet the competition of local firms which are closer to the market and have shorter lines of communication. In fact, it is often the emergence of local competition behind a tariff wall that prompts foreign firms to make direct investments to maintain their export markets.

The available evidence suggests that it is the largest firms located in concentrated industrial sectors that make direct investments: over 70 percent of total U. S. foreign direct investment has been made by

250-300 of the largest firms. The 187 multinational firms identified by Raymond Vernon control four fifths of the total foreign subsidiaries owned by the 500 largest U.S. corporations.

Technological advantages resulting from heavy expenditure on research and development are strongly associated with foreign investment. For example, U.S. direct investment in Brazil during the period 1956-61 was found to be related to possession of a technological advantage as measured by the proportion of scientists and engineers employed. In addition, however, it was also found that direct investment in the technologically advanced industries was more probable when the industry employed relatively large amounts of labor in the production process. On the other hand, in industries without a technological advantage, direct investment was more probable when large amounts of capital were employed. In short, some firms had a technological advantage over Brazilian firms and invested to lower their labor costs; firms without such technological advantages invested only when their access to low-cost capital gave them a competitive edge.

Capital, Technology, and Management

Advocates of direct investment claim it helps economic development in developing countries because foreign investors provide a package of capital, technology, and management and organizational skill. In particular, they contend that foreign investors are able to mobilize both local and foreign capital that otherwise would not have been invested in the country. And, they argue, multinational corporations control within their organizations technology which developing countries cannot obtain from any other source. Foreign investors are also able to provide uniquely qualified management that is capable of providing training for both local labor and management personnel. The advocates of foreign direct investment feel that multinational corporations, with their world-wide production and marketing systems, are able to facilitate exports from developing countries. At the same time, their presence breaks down local monopolies and exposes local producers to competition, so that prices are lowered for consumers.

The critics of direct investment reject many of these claims for uniqueness. They feel that the package of capital, technology, and management provided by the multinational corporation could be obtained from other sources at a lower cost to the developing country. Local capital is absorbed by foreign firms and thus diverted from local firms. The vaunted technology of multinational corporations may be used in the host country, but it is not fully transferred to nationals, since key technical and managerial positions are reserved for expatriates. Finally, it is felt that multinational corporations break up local monopolies only to impose stronger ones from abroad.

As might be expected, the evidence on these points is mixed. It is clear that foreign investors provide developing countries with a substantial amount of new capital every year, even though some of it is really reinvested earnings. In 1966, subsidiaries of U.S. investors in developing countries obtained 75 percent of their total funds from their parent companies, reinvested earnings and depreciation, and only 25 percent from the local capital market. And there is no question that foreign investors make advanced technology available to developing countries and train local managers and technicians in its use. Firms which spend substantial sums on research and employ large numbers of scientists and engineers are among those most likely to invest. And studies suggest that private foreign investors provide more technical and managerial training in developed countries for citizens of developing countries than do governments through aid programs. Multinational firms also seem to offer more training, and for a broader range of skills, than local firms in the same industry. As a result, less than 10 percent of managerial personnel and about 2 percent of technical personnel employed by manufacturing subsidiaries of U.S. investors in developing countries are expatriates.

There is a question, however, whether the technology transferred by multinational corporations is appropriate for conditions in capital-poor, labor-abundant developing countries. Foreign investors usually do little to adapt their production processes which were developed for use in industrial nations, and which consequently use little labor. The adjustments that are made usually are in peripheral activities like materials handling, or are dictated by smaller markets and short production runs. One reason that foreign firms may not adapt their technology is that they do not have to when their monopoly advantages insulate them from the necessity of minimizing costs. Moreover, distortions in the costs of capital and labor in developing countries reduce the incentive to use more labor. And, in many industries, alternative labor intensive technologies do not exist, or are inferior in terms of productivity and quality of product. Consequently, it is not unusual to find domestically owned firms using the same technology as foreign investors.

Cost to Host Countries

The major criticism of foreign investors is that the cost of this entire package of capital, technology, and management is too high. Foreign investors are accused of using their monopoly advantages and control to exploit the developing countries.

This accusation is difficult to prove. The table below shows that the returns on investments by U.S. firms in developing countries has not been greater than the returns earned in other developed countries outside of the petroleum industry. High returns on petroleum investments in developing countries largely result from transfer pricing policies which enable the oil companies to take advantage of depletion allowances when computing their U. S. income taxes. The high petroleum profits in developing countries are at the expense of quite low returns on refinery and distribution investments in developed countries.

Profits, interest, royalties and
management fees as percentage of
the book value of U. S. investments

	1970	1971	1972
All Industries			
Developing countries	20. 1	21. 8	22. 3
Developed countries	13. 0	13. 5	15. 0
Manufacturing			
Developing countries	14. 7	14. 1	15. 8
Developed countries	14. 9	15. 4	17. 9
Petroleum			
Developing countries	28. 6	35. 0	35. 3
Developed countries	5. 3	6. 0	7. 2

Source: Survey of Current Business, Sept. 1973.

Intra-firm sales. Earnings in the table are broadly defined to include profits, interest, royalties, and management fees. Yet it is often charged that reported earnings from these sources understate the true profits earned by multinational corporations on their investments in developing countries. Foreign firms supposedly extract large additional earnings from intra-company sales.

Several instances of such overcharging have been documented in Colombia, where subsidiaries in the pharmaceutical industry paid 155 percent more than the c. i. f. price for intermediate drugs imported from parent firms. Overcharging of 40 percent was also found in the rubber industry, 26 percent in the chemical industry, and 16-60 percent in the electronics industry. (Comparable data on transfer prices paid by subsidiaries in developed countries would be needed, however, to show discrimination among countries.)

While it is possible to dispute these figures, there can be little doubt that multinational corporations sometimes do use intra-firm sales to transfer profits out of developing countries, particularly when the host country limits dividend repatriation. The question is one of degree, i. e., the extent to which such methods are or could be used to exploit host countries. Their scope appears to be relatively limited. For example, total foreign payments, including remitted dividends and interest, of U. S. manufacturing corporations in Latin America were only 8 percent of sales in 1966, of which possibly 5 per cent was for imported goods.

We must ask why the parent would want to overcharge its subsidiaries. The principal reasons usually given are to reduce local taxes in countries where tax rates are higher than in other countries where the firm operates, and to circumvent restrictions on dividend repatriations. The possibilities for limiting taxes in this way have been considerably reduced by changes in the treatment of tax havens by tax authorities in developed countries. It may also be noted that manipulation of intra-firm transfer pricing greatly complicates the problems that multinational corporations have in controlling and evaluating the performance of subsidiaries.

Benefits to Host Countries

Each foreign investment has to be evaluated on a case-by-case basis in terms of the alternatives open to the developing country. The net effect of foreign direct investment depends less on the investor's monopoly power than on how efficiently the firm can produce in the host country, and on the host government's economic policies. There is much confusion about the relationship between the net benefits of direct investment to the host country and the monopoly power of the investor. It is usually thought that foreign firms with monopoly power will be able to extract even larger monopoly profits from developing countries by making a direct investment. However, the developing countries are already paying a monopoly profit when they import the product in question. There is no reason why the monopoly profit should increase, after direct investment, unless the host country pays the investor a subsidy that is larger than what is necessary to compensate him for higher costs of production. Regardless of the investor's monopoly power, it is almost always true that investments that do not receive excessive subsidies will benefit the host developing country. A foreign investment that can produce and sell competitively in the world market will produce some additional employment, or higher wages, or additional taxes for the host country. There may be negative external effects, such as the discouragement of local entrepreneurs, but the direct effect should be positive.

The situation is more complicated when it comes to investing in the production for the local market of goods that are not competitive with imports. In that case, the host country will have to pay what amounts to a subsidy, usually in the form of a tariff, to obtain the investment in the first place. The amount of the subsidy will depend on the extent to which diseconomies of scale, higher material costs, or inefficient labor raise production costs. Calculation of costs and benefits becomes still more complicated when the same tariff also benefits high cost domestic firms. It is entirely possible in many cases that the subsidy costs to the economy will exceed the benefits of local production by the foreign firm.

Government Policies

In recognition of this danger, developing countries are changing their policies toward foreign investors. During most of the last 25 years, governments have tried to encourage direct investment by indiscriminately granting tax incentives and tariff protection to foreign firms. In recent years, however, governments are beginning to place greater emphasis on the control of foreign investment. They have come to realize that favorable tax treatment granted by host countries has little effect on the basic decision to invest abroad. At best, tax incentives may induce a foreign firm to locate in one developing country rather than another, so the only effect is to stimulate unnecessary competition between them. Accordingly, many countries are phasing out, or limiting the application of, their tax incentives.

The change in attitudes has also been the result of increased knowledge about the characteristics of foreign investors. In particular, host countries have come to realize that monopoly and oligopoly characterize industries in which there are multinational firms. Consequently, they have attempted to devise policies that would improve their bargaining position vis-à-vis foreign firms. To this end, groups of countries, such as those in the Andean Common Market (Bolivia, Chile, Colombia, Ecuador, Peru, and Venezuela), have come together to formulate policy and present a united front rather than compete with each other for foreign investment.

The policies of the Andean Group are more restrictive than many others but are representative of the new directions being taken by a number of developing countries. These include limitations on the amount that can be paid as royalties by local firms (including foreign subsidiaries) for foreign technology. The purpose of this restriction is to eliminate competition by local firms for foreign technology, and thus reduce the price paid. The restriction is also designed to prevent foreign firms from using royalties to extract excess profits from the host country. A more controversial policy of the Andean

Group is the so-called "fade-out." The fade-out regulations require that foreign firms wishing to take advantage of the common market divest themselves of 51 percent of the subsidiary's equity over a 15-year period. Thus, foreign investments must either be, or become, joint ventures. [See Development Digest, January 1974, pp. 81-87, for discussion.]

Joint ventures with foreign firms having monopoly advantages are attractive to developing countries because they enable the countries to participate in the monopoly profits. However, not all foreign firms are willing to participate in joint ventures. Those which are vertically integrated with great interdependence among subsidiaries are particularly unwilling to relinquish control over one part of their international business system. Yet direct investment by such firms may be particularly beneficial to the host country because a substantial proportion of the output may be exported to the parent company. It is for this reason that the Andean Code exempts such export-oriented subsidiaries from the divestment requirement.

In Managing the Multinational Enterprise, Stopford and Wells suggest that joint ventures borrow more locally, pay out a higher proportion of earnings, pay higher prices for foreign technology, and are subject to more limitations on exports than wholly owned subsidiaries. Yet, many developing countries are willing to pay this price for the economic benefits of joint ventures as well as for the political benefits derived from the control of foreign investments. Indeed, political considerations are often as important as economic ones in shaping government policies toward foreign investment. It may be concluded that in the future developing countries will be much more selective with regard to foreign direct investment, and will press harder to obtain greater benefits for the local economy, and that multinational corporations, too, will be more selective in their investment policies.

[Extracted from "Multinational Approaches to Multinational Corporations," Finance and Development, Volume 11, Number 2, September 1974, pp. 27-29, 42. Washington, D. C.: International Monetary Fund and World Bank Group.]

Economic Nationalism and the Copper Industry

Theodore H. Moran

[Beginning with an analysis of foreign investor-host country relations, this article goes on to examine the sequel to the attainment of national control of mines and smelters by four major copper producers. The policies inspired by economic nationalism will need to be moderated if these four countries are not to find themselves suppliers of last resort, suffering disproportionately the impact of instabilities in the world market.]

Relations between Host Country and Foreign Investors

The most familiar frameworks for analyzing foreign investor-host country relations rely on game theory and bargaining models, especially the bilateral monopoly model. The foreign investor has the skills, experience, access to markets, and finance that the country needs to develop its resource base. The country has the ore-bodies, the labor force, and the control over taxation that can be mixed in some proportion to produce an attractive opportunity to the investor. Unless the host government loves foreign investors no matter how they behave, on the one hand, or is anxious to keep foreigners out no matter what the cost, on the other, then the terms under which a foreign investor will be allowed to enter the country and operate there constitute a problem in joint-maximization.

As both the foreign investor and the host govern-

Prof. Moran teaches international politics and economics at the Johns Hopkins School of Advanced International Studies, Washington, D. C.

ment try to increase their returns from the industry, each side has threats to make and benefits to offer. The struggle centers on the relative distribution of revenues that are being generated or that potentially could be generated in the industry. Some kinds of collaborative strategies can increase the size of the pie to be divided and increase the absolute returns to all parties. The host government must weigh the benefits of demanding a larger share of the existing revenue against the prospect of a larger absolute amount (but a smaller share) of revenue if the investor can be induced to expand operations. The foreign investor must weigh his prospects for further profits on the original investment against the chance for larger profits on expanded operation.

The bargaining models or game theory approach are not dynamic enough to show underlying trends in bargaining strength. For a preliminary approach to understanding these trends, one must add considerations about the role of uncertainty. The foreign investor starts from a position of monopoly control over the capacity to create a working operation out of a potential ore-body - a monopoly control that only a few alternative competitors could supply at a broadly similar price. There is always a great deal of uncertainty about quantity and quality of ores, whether the investment can be made into a success, and what the final costs of production and operation will be. The government would like to see its natural resource potential become a source of revenue and employment, but the government cannot itself supply the services needed from the foreign investor and is even less qualified than the investor to evaluate the risk and uncertainty involved. The strength of the bargaining is on the side of the foreign investor, and the terms of the initial concession are going to be heavily weighted in his favor.

Once an investment is made and the operation is a success, the whole atmosphere that surrounds the foreign-host relationship changes. A gamble with large risks has been won, and the host government is unlikely to want to keep paying premiums that reflect those risks for long. In the natural resource field, uncertain investments are frequently turned into bonanzas, and the distribution of benefits from such ventures invariably has the appearance, in retrospect, of the strong (company) cheating the weak (country). If a perception of injustice is not felt after a time by the government that originally negotiated the agreement, it can easily be created by the opponents of that government. And with the investment sunk and successful, the host country is in a position to bring pressure for renegotiation. At the same time that the first mines are successfully opened, uncertainty about the existence of ore-bodies and about the structure of production costs has been reduced for subsequent investors. The government can drive a tougher bargain with later entrants, and this in turn increases the leverage in demanding revision of the original concesssions to put them in line with the later agreements.

In short, with the reduction of uncertainty the bargaining strength inevitably shifts from the foreigners toward the host government. In fact, since the end of the Second World War few successful concession agreements in developing countries - in ferrous and nonferrous metals, petroleum, sulphur, and natural gas - have remained long unaltered. In mining and drilling industries where investment for new production or processing facilities must come in large discrete lumps, the shifts in bargaining power are repeated before and after each new major corporate commitment. Before the investment for new production capacity, a new smelter, or a new refinery, the relative weight of bargaining strength tilts in favor of the foreign investor; after the operation is successful, it begins to tilt back toward the host country.

Producer country learning. A country that has no history of large natural-resource concessions begins, in all likelihood, with a very inexact knowledge of the extent of its mineral or petroleum wealth, and has very little independent capacity to check the feasibility studies or exploration reports presented by foreign investors. In much of the Third World before the Second World War - even in regions not formally colonized - initial investments in resource extraction were undertaken with only the most primitive attempts at bargaining. In Chile, for example, Anaconda and Kennecott were rewarded for their risks in the Atacama Desert or Andes mountains in the early twentieth century with copper concessions that entailed almost no taxes or other obligations. Early international investments in tin, bauxite, zinc, and iron ore were made under much the same conditions. Successful ventures, however, provide an incentive for the host country to develop skills and expertise appropriate to the industry. Beginning with elementary attempts to tighten the bargaining process, the country begins to move up a learning curve that leads from monitoring industry behavior to replicating complicated corporate functions.

The incentive to chip away at the foreigner's monopoly on skills and expertise is magnified as demands for a larger share of the revenues grow and as claims on those revenues multiply. When the oil companies first established themselves in the Middle East or the mining companies in Africa and Latin America, the fiscal needs of the host governments were little more than the personal expenses of their followers and the patronage of their political clientele. But as the Second World War and de-colonization brought social mobilization, urbanization, and import-substituting industrialization to these regions, the idea of playing the game of joint maximization more aggressively with the foreign companies began to become a crucial political issue around the world.

Even those governments most sympathetic to the foreign companies have not been immune to such pressures, and did not hesitate to respond to them when the balance of power was favorable. In Venezuela, President Pérez Jiménez, who overthrew the more "nationalistic" Rómulo Betancourt in 1950 with the promise of helping the foreign oil companies, found that he needed ever more revenues to finance urban construction and industrial growth. He provoked a crisis in the international industry in 1956 by withdrawing options held by the established producers and auctioning off large concessions to new companies more willing than the old ones to expand output. Successor governments in Venezuela pushed the host-country share of petroleum revenues above 70% in the 1960s with a national commitment to "milk the petroleum" for development.

The value of incremental revenues to sustain growth and/or to dissipate social tensions in countries that are undergoing rapid development and social mobilization is too high, and the political temptation too great, to allow foreign companies undisturbed collection of their monopoly rents. For a country where additional foreign exchange revenues can boost the economic growth rate to 10% per year, the true social return on the increment available for investment is above 20%, while a postponement of that increment for five years reduces its value by half. For a country (with a high or a low economic growth rate) where there is a threat that stagnation may bring social turmoil - or merely electoral displeasure - political elites must make a calculation even more heavily weighted toward developing skills in the present. In short, the development process magnifies the benefits that can be gained by improving the ability to push against foreign companies, and magnifies the costs that will be borne by leaders unable or unwilling to push.

Consequently, as the host-country moves up a learning curve of bargaining skills and operating experience, its relations with foreign investors in the industry do not merely swing back and forth. In time, the country may acquire skills sufficient to operate the industry directly. As the host develops this ability to imitate or duplicate the functions of the foreigner, the cost of nationalism rapidly diminishes.

Nationalization in the Copper Industry

The mid-1960s marked a peak in the flow of equity venture capital to develop or expand copper-mining facilities in "insecure" countries of the underdeveloped world. By the beginning of the 1970s, economic nationalism had gained acceptance. General Velasco had taken over the government in Peru, and, after the nationalization of the International Petroleum Corporation, had imposed stiff new controls over the copper industry. The nationalization in Zaire had been completed. To the south, in Zambia, President Kaunda had taken over 51% of the operations of Roan Selection Trust and the Anglo-American Corporation - thereby damaging, at the same time, the interests of American Metal Climax and the Rio Tinto Zinc Corporation. Eduardo Frei in Chile had nationalized Anaconda, and Salvador Allende had followed with rapid take-overs of Kennecott and Cerro as well.

All the new nationalistic producers faced the subtle problem of how to make successive governments and their opponents recognize that the cautious manipulation of interdependence (with other producers, including the private corporate producers, as well as with fabricators and consumers) leads to greater strength than the raw exercise of autonomous power. The cautious manipulation of interdependence requires self-restraint and dependability in the use of market power. Further, it requires the ability to make a credible promise that the self-restraint and dependability will continue into the future. For this, the heritage of economic nationalism does not provide a good preparation.

The immediate reaction to the challenge of economic nationalism by the traditional giants in the international copper industry - both those directly affected by nationalizations and those not directly affected - has been simple and predictable: (1) they have shifted their investment plans and their exploration efforts to "secure" areas; (2) they have tried to keep their former market share by "replacing" threatened or lost output; (3) they have been trying to preserve their network of ties to customers, to maintain the selling patterns that they built up with such effort, expense, and patience in the past.

Following nationalization, neither Chile, Peru, Zambia, nor Zaire were willing, in a situation of bilateral oligopoly with customers, to share the burden of fluctuations in supply and demand. They have not given fabricators and consumers a "secure" source of supply. During the course of the Vietnam War, the prices borne by the customers of these four countries rose from about 35¢ per pound to levels frequently about 80¢ for sales in the London market, while the U.S. producers' price stayed from 20¢ to 30¢ per pound lower. Not only did these producing countries try to use full market power during periods of strong demand by leaving the low U.S. producers' price and switching to the higher open market price, but they also sought to cut back production when demand sagged in order to maintain prices at the high level. In 1967 Chile met in Lusaka with representatives of Zambia, Peru, and Zaire to form a producers' organization, the Intergovernmental Council of Cooper Exporting Countries (CIPEC), modeled after the Organization of Petroleum Exporting Countries, to coordinate price and production policy. At least three times since the Lusaka Conference, the CIPEC countries have tried to obtain agreement for cut-backs in production when prices dropped to force them back up. Each time the divergent interests of the member countries have prevented effective harmonization of plans for production quotas during periods of slack demand. But the intent of the independent national producers was clear: the new state agencies of these four countries would try to take advantage of short-run inelasticities of supply and demand at each stage of the business cycle to gain the most revenues possible to fund their needs for national welfare and development. The strategy of the CIPEC countries - to confront customers with full market power at every stage of supply and demand - was precisely what the processors and consumers wanted most to avoid.

Such a strategy would work only if consumers had no feasible alternatives. Unfortunately for CIPEC, many major consumers (and their governments) are beginning to calculate the costs of one alternative - namely, integrating backward to their own "secure" supplies - and finding that the results may be worth the effort. The initial CIPEC strategy of capitalizing on the position of strength under conditions of extreme copper shortage (1966-1969) provided the stimulus for industrial fabricators and consumers, and their governments, to take unprecedented steps to develop new sources of copper. Such steps have now been continued even through periods of weak demand.

For the first time, the West German government has been following the pattern of the Japanese in financing new mining operations on the basis of repayment in ore. The Kreditanstalt für Wiederaufbau, the German state reconstruction bank, has lent substantial amounts of development capital to American companies in Southeast Asia and Oceania and to British and American companies in some parts of Africa (not Zambia) in return for long-term contracts for a share of the output. West German, Swedish, Belgian, and French capital have flowed to Canada to finance or take equity participation in new mines. The Pechiney-Tréfimétaux group in France, formerly interested primarily in aluminum and nickel, are becoming copper producers in Australia. The Japanese Ministry of International Trade and Investment, coordinating the efforts of governmental agencies, private trading groups, banks, and mining and fabricating companies, has continued that country's voracious search for copper in Canada, the South Pacific, Southeast Asia, and some parts of Africa.

In sum, the consumers and fabricators of copper in the major industrial countries have been integrating backwards to develop their own secure sources. Their governments have been encouraging them to move upstream and have also been supporting the formation of other mining companies that can be depended upon to be regular suppliers of copper. CIPEC use of untempered "monopoly power" in the past, inspired by Chile, has stimulated this movement to weaken the producers' oligopoly.

Dangers of Market Dualism. There is a danger posed by the pricing and marketing strategy of the CIPEC producers that is more immediate than the long-term effects in reduction of their world market shares. It consists in the potential development of a dual market system in which the CIPEC countries gradually become suppliers of last resort, outside the main network of semi-integrated ties between corporate producers and consumers, onto whom will be shifted the major costs of uncertainty about supply and demand for the entire industry. The reason for the evolution of a new dual structure lies in the persistence of a preference among consumers for ties of informal integration to the mining state - ties that the new independent state producers have been unwilling or unable to maintain.

The impetus for vertical integration can come from two directions - from producers who want "secure" outlets, and from processors or consumers who want "secure" sources of supply. "Security" is a judgment about the relative risk that the producer, processor, or consumer runs of meeting sudden market power being wielded against him - especially market power wielded unevenly against himself and not against his competitors - at some stage that he does not control. If there is a high risk, he measures the cost of the threat to his operations against the costs of neutralizing or minimizing the threat. Calculations of this sort are impressionistic and subjective. But they are the basis for strategy. The formal and informal bonds of vertical integration in the copper industry were built up because inelasticities of supply and demand in the short run had tended to shift market power abruptly back and forth from producer to fabricator or consumer. In a situation of bilateral oligopoly such as this, where there is a large exposure to risk, both sides may be willing to pay a premium to reduce that exposure.

From the point of view of the consumer in the international copper industry, the risk of large blocs of copper being removed unpredictably from the market, creating sudden and severe shortage, remains high. Transportation difficulties for Zambian copper moving through Rhodesia or Tanzania create periodic uncertainty about delivery, as do port strikes in the United States or Europe. A cave-in at Mufulira in Africa in 1970 took 150,000 tons, or 20% of Zambian production, from the market in one blow; a mudslide in West Irian or Bougainville in the monsoon season of the South Pacific could do the same thing. New production simply cannot be brought on-line in the short run in time to prevent a sharp rise in price with an absolute shortfall for many users, and a temporary switch to aluminum, plastics, or specialized steels is not easily accomplished at the margin by fabricators, nor, once accomplished, easily reversible.

These risks have been compounded by labor difficulties. Twice in the 1960s there were prolonged strikes among copper workers in the United States, cutting off almost all American production. As the CIPEC countries move toward complete national control of production, their labor problems appear to be becoming more serious, too. In the past, despite frequent short strikes, the aggregate production record of Chile, Zambia, Peru, and Zaire has been quite good. Allende's efforts to keep Chilean miners' salaries within the limits of his stabilization program, however, provoked a 75-day strike in 1973 and the stoppage of all exports for almost three months. It may prove to be more difficult than it was with private companies for governments with direct control to minimize strikes and keep production costs competitive while insuring a steady flow of output. Already the costs of production in CIPEC countries have risen sharply, due in part to pressures for increasing employment in national industries.

An additional uncertainty for consumers has been introduced by the debates in various CIPEC countries, especially Chile, about selling copper to communist countries. The major problem in this for consumers is uncertainty in the face of inelastic supply - not ideology. If some or all of the CIPEC countries were to establish regular trading patterns that allocated, for example, 10% of their annual output under long term contracts to Eastern Europe and 5% to China, the uncertainty would be removed. But there is no predictability about supply when trade policy changes, or threatens to change, with each new President or each new Congress or each new state administrator.

To hedge against the threat of undependable supply, against the threat of market power being wielded unevenly against them, the major copper consumers have been continuing to show a strong preference for establishing ties of formal or informal vertical integration. The private corporate producers are responding sympathetically to that preference, as they have for decades. The new national producers are not. The danger for the new independent national producers is that they may end up paying the insurance premium for the entire international industry. The major private corporations and their governments may well not have to bear most of the costs of maintaining excess capacity, or maintaining inventories, or providing consumers with insurance against meeting unavoidable monopoly power at the production stage. The national producers may find that their policies will lead them to be forced to accept those costs for the entire industry.

It is quite possible that planners in the governments of Chile, Peru, Zambia, and Zaire have too easily accepted the conventional marxist argument that large industrial societies need the raw materials of the Third World and will collapse without them. This has led the nationalists to assume that by controlling the sources of raw materials, they would be in a position of consummate strength. But there is nothing in history or logic to suggest that corporate boards of directors will simply sit and let the price and terms of supply be dictated to them by outsiders if they have other options available to them. Without the necessity of alleging either malice or conspiracy, it is now evident that fabricators and consumers and their governments are willing to act to the extent of their powers to protect themselves.

By adopting the strategy of using the full extent of their market power at every point of the business cycle, the independent national producers offer no incentive for a fabricator or consumer to maintain ties with them rather than seek alternative sources or integrate backwards to develop supplies of its own. They make themselves into suppliers of last resort. Their share of world production is still in the early 1970s sufficiently large (35%-40%) that there cannot and will not be a massive defection from them as suppliers. But there has been a trend for major consumers to try to cover the bulk of their needs from the semi-integrated system of corporate producers as fast as the companies can expand output, while treating the CIPEC production more and more like a spill-over market. If consumers cover the bulk of their needs from sources in the integrated industry during both the expansion and the contraction phases of the business cycle, a 10% variation in aggregate demand that is passed onto the CIPEC market would require a 30% change in production (or inventories) for them, and a much greater change in net revenues.

Those proud and independent nationalists will find their small (and probably competitive) market getting only the notoriously unstable edge of demand. Industrial consumers will provide for the majority of their orders through scrupulously regular positions on the sales books of the major private producers, reserving for the independents only the variable margin of their needs. If the CIPEC countries make themselves into a spill-over market as suppliers of last resort through the full use of their individual or collective market power, they will operate at full capacity only in the boom phase of the industrial business cycle, and hold inventories for the entire industry (or clear their production in price competition with each other at discounts that may fall below average cost) the rest of the time.

Alternatives. There seem to be two clear courses of possible evolution for the relations between the new independent national producers and the larger world industry: First, there is the course that has been followed thus far, in which the independents continue systematically to break ties, pursuing something called independencia or autonomia, and scorning close dependable relations with final customers in the large industrial countries. Second, there is an alternative course, in which the independents seek reintegration with the world industry, reestablishing informal vertical ties of their own and conducting themselves like the other producers, recognizing and emphasizing and taking advantage of interdependence. It requires a moderation in coordinating production that is not aimed at exploiting inelasticity of demand to the fullest extent possible in both boom and slack markets. It requires, in effect, joining the oligopoly and playing according to its rules.

There is no reason why, with proper stress on performance and realiability, the economic nationalists cannot occupy a position within the international industry as strong or stronger than any private multinational copper corporation. Unless the CIPEC countries deliberately fashion a price and marketing strategy to make themselves into suppliers of last resort, the large corporate consumers may come one day to consider them suppliers of first resort - if their domestic pressures for foreign exchange could be translated into policies that would limit any long interruptions in production. In the United States, Western Electric and General Electric, General Motors and Westinghouse will be happy to import a regular portion of their needs from Chile if the country will insure them of dependable supplies in the event of a domestic strike. In Europe and Japan, British Insulated Callender's Cables, Norddeutsch Affinerie, Volkswagen, or Mitsubishi will continue to be content to get most of their copper from Chile, Zambia, Peru, and Zaire, even with the increasing penetration of their economies by vertically integrated foreigners, if they are not put at a competitive disadvantage to their rivals from the United States. What the CIPEC producers must devise is a pricing and marketing strategy calculated to moderate the pressure felt by fabricators or consumers to integrate backwards themselves, and to eliminate the pressure felt by the fabricators or consumers to seek closer and more durable ties with alternative producers. In short, the new national producers must carefully learn to treat the consumers in the industrial countries exactly the way the multinational corporations do.

[Extracted from Chapters 5 and 7 of Multinational Corporations and the Politics of Dependence: Copper in Chile, pp. 157-167, 226-244. Princeton University Press, 1974. Copyright©, Princeton University Press.]

International Sub-Contracting

Michael Sharpston

[Over the last ten years there has been a rapidly increasing tendency for firms in developed countries to contract-out to producers in developing countries the manufacture of certain products or components, and the performance of certain processes. Final sales are in developed country markets. This paper assesses the current scope of that phenomenon, analyzes the reasons for its growth, and considers its economic and political effects.]

There is no agreed definition for international sub-contracting. The definition used here is: all export sales of articles which are ordered in advance, and where the giver of the order arranges the marketing. International sub-contracting can be divided into the sub-contracting of processes, sub-contracting components, or sub-contracting whole products. The types of firm giving the sub-contract may be producer firms, i. e., overseas organizations which themselves produce similar products (e. g. Mortorola, Texas Instruments), or retailing firms (e. g. Sears Roebuck). A wide range of possibilities exist with regard to the business relationship between the principal and the sub-contractor. The sub-contract itself may be long-term, short-term, or for a single batch. The principal may own a minority, majority, or the whole of the equity of the sub-contractor. He may provide loan capital; he may also provide physical equipment for the sub-contractor. Furthermore, the principal may provide technical assistance to the sub-contractor. There are many possible combinations of these various forms of business relationship, so that in

Mr. Sharpston is an economist with
the World Bank, Washington, D. C.

practice a complex range of business relationships between principal and sub-contractor exists all the way from the sub-contractor being a wholly owned subsidiary of the principal to single-batch sales at "arms' length." All forms of international sub-contracting have one important characteristic in common: sub-contracting avoids the problems of marketing.

A typical example of the type of international sub-contracting which has arisen in recent years is that for semi-conductors: in 1973 the United States had imports from developing countries worth $190.7 million of semi-conductors with some American components. The wafer which is the heart of the semi-conductor is exceptionally light and typically smaller than a fingernail: it is fabricated in the United States. The wafer and other components are then flown to say, Taiwan, where labor costs for assembly are about one-tenth of American ones. Under magnification, the gold threads are soldered to the terminals, and the finished semi-conductor is flown back to the United States. About 40 percent of the gross value of the returned U.S. import is the value of the U.S. components, so that the value added in the developing countries would be $113.6 million of the $190.7 million. In a recent study, not a single U.S. semi-conductor firm answering the questionnaire did not have off-shore assembly facilities, and European firms have been forced to follow suit or cease production.

The Current Scope of International Sub-contracting

One source of quantitative data on international sub-contracting is Economic Factors Affecting the Use of the Items 807.00 and 806.30 of the Tariff Schedules of the United States (U.S. Tariff Commission, September 1970). Customs items 807.00 and 806.30 permit an importe under certain conditions, to pay duty for the product imported only on the value added abroad; no duty is paid on the value of the U.S. parts or materials incorporated. Not all products which involve international sub-contracting will necessarily qualify under these customs items; and the Tariff Commission report only deals with U.S. imports. Nevertheless, it is easily the most important source so far available.

U.S. Tariff Commission data give some idea of the rapid growth of international sub-contracting (Table 1). The share of developing countries in U.S. imports under these two tariff items rose from 6.4 percent in 1966 to 35.9 percent in 1973. U.S. sub-contracting in developing countries in 1973 was twenty-five times the 1966 level, an annual compound growth rate of about 60 percent for seven years. Information on the amount of sub-contracting arranged by firms from other developed countries is rather fragmentary. The increase in Japan's use of international sub-contracting in the late 1960s was also very rapid as indicated indirectly by some investment data.

Table 1. U.S. Imports under Tariff Items 806.30 and 807.00, 1966-73 (Value in millions of dollars)

	1966	1967	1968	1969	1970	1971	1972	1973
Total Imports (as specified)	953	1035	1554	1852	2213	2768	3709	4247
Imports from developing countries	61	99	222	395	542	653	1032	1323
Dutiable value of imports from developing countries*	31	43	98	177	246	314	531	827

*value added overseas plus freight cost.

Source: U.S. Tariff Commission, published and unpublished data.

Reasons for the Growth of International Sub-contracting

Demand for international sub-contracting is a derived demand: it depends on the pattern of demand for final products in the developed world, their method of manufacture, and cost differentials. Among final products, in recent years new labor-intensive products in the electronic field have been added to the old labor-intensive manufactures such as clothing and shoes. There has been buoyant demand for products which require labor-intensive manufacture. Within this structure of final demand, demand for international sub-contracting has principally been in response to the differential between labor costs in the developed and the developing countries; this differential has been rising and is likely to continue to do so. Even if U.S. wage rates go up by 5 percent, and Korean rates by 20 percent, the absolute differential between the rates becomes larger. Furthermore, for certain tasks, it has increasingly been found possible to obtain labor productivity in the developing countries close to, or exceeding, U.S. levels. At the same time the logistics of an overseas sub-contracting operation have become easier. There have been developments such as increased availability of air freight facilities, and containerization; and telecommunications have greatly improved between many developing countries and the major industrial nations. Demand for international sub-contracting has also, to some extent, been encouraged by governmental regulations in developed countries. Several developed countries have tariff regulations which permit low effective tariffs to be levied on the further processing abroad of semi-manufactures produced in the developed country.

Despite the importance of the factors mentioned, it would probably be a mistake to see the enormous rise in international sub-contracting as having been solely due to an objectively ascertainable change in comparative costs. Attitudes also have changed; there has been an increasing willingness among firms now called 'multinationals' to think in terms of world-wide production and marketing possibilities, rather than treating overseas operations as separate from their operations in the home country. The move to international sub-contracting has been in the nature of an innovation in production systems: the pioneers in a particular industry have typically soon been copied by a wave of competitors, who often establish sub-contracting facilities in the same overseas countries as the pioneer firms. Similarly, American use of international sub-contracting has forced European and Japanese firms to follow suit.

On the supply side, developing countries have shown an increasing readiness to make themselves available for international sub-contracting operations. By the late fifties and early sixties many countries had found import substitution an unsatisfactory method of industrialization, particularly for small countries where there were serious difficulties in obtaining adequate economies of scale. It is no coincidence that international sub-contracting has been most in evidence in countries such as Hong Kong, Singapore, Taiwan, and Korea, where the small size of the domestic market made open economic policies particularly desirable. At the same time, there was a growing emphasis among development economists on export- rather than import-substitution, and indeed this has now become the new orthodoxy, affecting government policy in quite a few developing countries. An increasing minority began to open up their economies, making importation and exportation easier, and often also providing certain direct or indirect subsidies to export industries. Within this field of exportation, international sub-contracting permitted access to developed country markets without the risks and problems connected with foreign marketing. In many cases - for example, the supply of certain components of a product or the performing of certain processes - direct exportation was not in fact a feasible alternative to international sub-contracting. Through international sub-contracting, a developing country might obtain technical assistance, and often capital, without which the industrial operations involved might not have been possible. Thus from the mid-sixties onwards there was an increasingly favorable environment, on both the demand and the supply side, to the rapid growth of international sub-contracting.

Labor costs. It is possible to find cases of international sub-contracting which depend on the low cost of production inputs other than labor; for example, alumina is imported into Ghana for processing into aluminium and subsequent re-export, solely to take advantage of a very low rate for electric power. Nevertheless, labor-intensity of a product or process is the most typical reason for which international sub-contracting in developing countries occurs. However, labor cannot be regarded as a single, homogeneous, factor of production. Unskilled labor is indeed plentiful; but skilled labor often is not, and in many countries supervisory and management personnel are extremely scarce. The availability of different types of labor varies widely across the developing world. In Morocco, for example, salary scales for Moroccan or locally recruited European supervisory personnel are as high as in Europe; if it is necessary to import expatriate senior staff, costs in Morocco are 25-30 percent above that cost of equivalent grades in Europe. In many countries less developed than Morocco, costs of supervisory personnel could be double those of Europe. In some Far Eastern countries, however, certain grades of skilled labor and supervisory personnel are now available at low wage rates relative to the rest of the world.

International sub-contracting operations in developing countries tend to be intensive in their use of unskilled or semi-skilled labor, but not intensive in their use of skilled labor or professional manpower. Manual dexterity of a high order may be required, but the typical international sub-contracting job is one which can be learned in roughly six weeks, perhaps from the base of traditional skills. Thus in Morocco, in six weeks girls (who may not be literate) are taught the assembly under magnification of memory planes for computers - this is virtually darning with copper wire, and sewing is a traditional Moroccan skill. Of the total 807.00 imports into the United States from developing countries in 1969, for example, the major items were:

	%		%		%
Textile products	8.6	TV apparatus	8.3	Electronic memories	10.2
Office machines	8.3	Semi-conductors	23.6	Toys, dolls	5.9
TV receivers	10.8				

For all these products the sub-contracting operation would typically have consisted principally of assembly work; and these items alone constituted over three-quarters of the gross value of all 807.00 imports.

Because most developing countries lack an industrial tradition, it will often be necessary to have a higher ratio of supervisory personnel to manual workers than would be required in a developed country. But physical output per manual worker may often be similar to that in developed countries, and in some cases higher. The 1970 study of the U.S. Tariff Commission found the greatest difference between labor productivity in the United States and overseas in the case of garment-making in Mexico where it was about 60 percent of the U.S. level. For electronic assembly, foreign labor productivity was about 92 percent of the U.S. level, and for other items the productivity differential was still smaller, even in some cases negative.

More recent research indicates worker productivity in the Mexican Border Industrialization Program at 80-140 percent of U. S. levels. High labor productivity is also found in Korea. In Morocco in 1972, management in many plants estimated labor productivity under similar conditions to be 85-90 percent of the European level. There is some evidence that a comparison of labor productivity in developed and developing countries is most likely to be fairly favorable to the developing country for machine-paced jobs.

It is also likely that labor productivity in some international sub-contracting operations is increasing rapidly over time as the labor force gains industrial experience. Labor turnover and absenteeism may also be lower than in a developed country. One must consider that jobs suitable for international sub-contracting are often low-grade, undesirable jobs in developed countries; in developing countries, however, the same jobs are often highly sought after. In many such countries high urban unemployment makes any regular employment very desirable, and factory conditions will often be pleasant compared with working conditions in other jobs. Whereas in the developed country, the job will typically be very ill-paid relative to other jobs, in the developing country the opposite is usually the case.

Even where labor productivity in a developing country is substantially below normal levels in the developed world, differences in wage rates are so great that it may still pay a multinational corporation to do international sub-contracting. Comparisons of annual average hourly earnings in manufacturing in 1970, for example, show: averages of $3. 00 or more in the U. S. and Canada or $1. 50-2. 50 in northern Europe, as against averages of $0. 30-0. 50 in Latin America and still less in much of Asia - e. g. $0. 15 in Sri Lanka. The differentials in particular labor-intensive jobs may be even greater than among national averages. Thus in 1967, U. S. wages in garment-making were about twenty times those in Korea. In 1972, an hour's workshop labor by an electrical worker would be costed at U. S. $0. 80 per hour in Morocco, as against $3. 00 to $3. 50 per hour in France (all overhead costs included). Typically, labor productivity differentials in favor of the developed country - where they exist - have little effect in eliminating the vast differential in wages. Thus according to U. S. Tariff Commission data, the net Far East labor cost for electronic assembly would be only 8 percent that in the United States.

At first sight, it may seem difficult to reconcile such wage data with the fact that, in very many cases, technical costs of production for the domestic market are far higher in a developing than in a developed country - not only non-labor costs but labor costs as well. In production for the domestic market of a developing country, production runs are often far shorter than in a developed country, with a consequent need for the frequent time-consuming and expensive re-tooling between runs. Often management is inferior; and for small-scale operations high-grade management would often be uneconomic as constituting too high an overhead. With international sub-contracting, however, production is for developed country markets, so the production runs and size of plant can be those found in developed countries. Multinational corporations can obtain management of similar quality. Machinery available can also be identical. Alternatively a multinational corporation moving production to a developing country may often be able to achieve an even greater fall in total costs of production by some substitution of labor for capital. For example, low labor costs may make it cheaper to use hand labor rather than machinery for certain packaging or assembly operations, or permit profitable processing of scrap where this was not an economically viable operation in the developed country.

Suitability for international sub-contracting requires that a particular product or process must be labor-intensive in *developed* countries. For example, the overall production of semi-conductors is both skill- and capital-intensive, but one particular phase in production - assembly - is very intensive in its use of easily trained labor, and accordingly, semi-conductors are an extremely common object of international sub-contracting. The labor-intensive production processes in manufacturing are those which for one reason or another have resisted the whole trend of technology in the developed countries, which has been to mechanize production wherever possible. Very often, these processes are assembly operations; or certain kinds of finishing operation (e.g. cleaning, buffing and polishing), particularly of complex shapes. Another case is sand-casting: this is typically labor-intensive work of a hot, messy kind which workers in rich countries do not like (and can afford not to like).

Perhaps the most important single operation which resists mechanization is sewing: industrial sewing of clothing really resembles, quite closely, sewing with a domestic sewing machine. This makes garment-making an ideal operation for international sub-contracting, from the technical point of view. For the cutting, one can use laser beams, and computer-designed patterns to reduce waste; but 80 percent of the labor cost of clothing manufacture is in the sewing stage, and this is extraordinarily difficult to mechanize. For a long time garment-making is likely to remain labor-intensive, and a factory with quite advanced machinery still only represents a fixed investment of around $2,000 per work place, of which the building itself is the largest part. Fixed investment per work place in a modern textile plant can be seven or eight times as large. And there are equivalents to sewing in the electronics field: for example, the manufacture of electronic memories which would be most difficult to mechanize. There is also an equivalent of a kind to sewing in metal-working: soldering and welding.

One situation in which most production processes tend to be labor-intensive is the production of any type of article at all in small production runs or non-standard sizes. Short production runs do not permit the amortization of highly specialized and automated machinery. In an enormous variety of industrial fields, practical discussion of international sub-contracting possibilities boils down to: 'Where are the short production runs?' It applies for electric motors, electronics, vehicle parts, railway wagons, pharmaceuticals. For a short production run any country will have to use simple technology, and production will, therefore, be labor-intensive. Indeed, firms in developed countries may not want small volume work; it disrupts large factories. In this way, a Moroccan firm recently won an international sub-contract to make refrigerators. Of course, small production runs by developed country standards may be still very large for a developing country, and the Morocco refrigerator firm in question will now triple its total annual production. One field where quite short (hence labor-intensive) production runs still predominate even in developed countries is machine tools; it is therefore a possibility for some of the more advanced low-wage countries. Spain, for example, is building up a substantial export business in simple low-grade machine tools. Although short production runs can be a very good way into international sub-contracting, it would be wrong to suggest they are the only long-term international sub-contracting possibilities. In Taiwan and Singapore, electronics firms are now setting up plants for long production run manufacture of radios and television sets for the world market.

In broad terms, automated production has the advantage of repeatability and precision, while labor-intensive production has the advantage of flexibility. Thus the aircraft industry commonly uses automated techniques, for reasons of precision; conversely an industry using a natural material which is expensive and non-uniform (e.g. leather) will keep to labor-intensive techniques, for reasons of flexibility - a man can adjust the cut he makes to the individual piece of material. The superior flexibility of labor-intensive techniques is also an advantage in a situation of very rapid technological change. This can for example be an important consideration in electronics.

Labor-intensive international sub-contracting possibilities are not confined to non-agricultural products. Preparing food for processing often involves a good deal of hand labor: taking off shells or husks, cleaning, and so on. As a result, the frozen strawberry industry is tending to move out of the southern United States into Mexico. International sub-contracting is also possible for services: aircraft-servicing and ship-repair (e.g. in Singapore), card-punching of data for computers (e.g. in Jamaica), printing (e.g. in Hong Kong).

Freight and "distance" costs. Freight costs and other costs associated with distance are another major factor affecting the feasibility of an international sub-contracting operation, particularly for the sub-contracting of processes. In this latter case, a production system can only in effect be split up if the costs of double haulage - to the developing country and back to the developed country - are sufficiently small. (Separation of a process may also involve special extra costs, such as reheating, wrapping, protective greasing of metal, etc.). Freight costs vary with many factors, but the critical factors are typically weight and bulk. Because parts have a higher value-to-weight ratio, international sub-contracting is usually easier in electronics than for electrical goods, and easier for electrical goods than for most mechanical engineering products.

One effect of freight costs is of particular interest. High freight costs act in favor of import-substitution, but against exporting. This may create openings for international sub-contracting by some developing countries for markets in other neighboring developing countries. Here high freight costs can make it easier for certain developing countries to engage in international sub-contracting. The more industrialized developing countries may be able to manufacture certain products or perform certain services which neighboring less advanced countries need; and their proximity and their low wage-rates relative to the developed world may make them competitive. For example, Morocco repairs electric equipment for Algeria, and sells radiators for special purpose vehicles to Senegal. For this type of international sub-contracting, the transport costs involved in a bulk-creating process (e.g. assembly) could be a favorable factor, since they create natural protection from competition by developed countries further away. International sub-contracting for other developing countries could also provide a training ground in which to gain exporting experience and improve quality standards.

In addition to freight costs, important costs are incurred in international sub-contracting simply because of the distances involved. The logistics of the operation are far more complex than for production within the plant of the principal. The 'pipeline' is longer, with more points at which it can be interrupted: inventory might need to be one or two months' production, rather than only a few days. There are also the costs and problems of communication, and the executive travel time involved. With greater distance, modification of product specifications as a result of afterthoughts or in the light of experience becomes much more cumbersome, a particularly important consideration with 'one-off' operations or short production runs. The combined impact of freight and distance costs is evident from the success of Mexico in international sub-contracting for the U.S. market despite its comparatively high wage-rates.

A point of the utmost practical importance is the way in which developing country governments can artificially increase effective "distance." Casablanca, the main industrial center in Morocco, is three hours by air from Paris, and three days by sea from Marseilles. However, importation of an article for processing and subsequent re-export will involve *importation en admission temporaire*. Because of the complex bureaucratic proceedings to be followed, the "administrative distance" from Europe to Morocco for imports becomes two to three months. Similarly, the Moroccans are anxious about flight of capital via the under-invoicing of exports, and impose various checks: this creates further delays and expense for a potentia sub-contractor in Morocco, and may make him feel he is under suspicion. As against this, the countries well known for sub-contracting have relatively less severe barriers to the free movement of goods. Indeed, Mexico has an entire border strip with the United States as a free trade zone. Hong Kong and Singapore are essentially free ports.

The influence of governments. The governments of developing countries, in many cases, impose such severe bureaucratic obstacles to international sub-contracting as to render it almost impossible. Usually, this is the actual effect, and not the aim of government policy; but it is probably no coincidence that so many developing countries have severe institutional barriers to international sub-contracting, and indeed more generally to exporting. Industry tends to be inward-looking, with a built-in tendency, often fostered by an over-valued exchange rate, to believe that it cannot be competitive on world markets. Quality standards will be at the minimum level required in a heavily protected market of poor consumers. Importing is not only subject to high tariffs or to quotas, but is also made very cumbersome by bureaucratic barriers. Fears of capital flight can create almost equally severe barriers to exporting. More generally, there is an atmosphere of *dirigisme*. Most developing countries are geared to planning via controls; and market forces, particularly international market forces, are viewed with deep suspicion. I. M. D. Little's aphorism, "Planners do not like exports," is barely an overstatement: the planning ideology does tend to foster autarky. And bureaucratic barriers to the setting up of the actual sub-contracting plant can also be a very important disincentive to sub-contracting operations.

While many governments of developing countries still hinder international sub-contracting with severe bureaucratic obstacles, a few are now turning to export- rather than import-substitution, and providing substantial incentives to trade and exportation. A prominent example is Korea. Firms engaging in international sub-contracting get subsidized credit for their working capital. Allowances for materials wastage in processing are very generous and allow a hidden profit from sales on the home market. Direct or indirect export subsidies (including bonus exchange rates) can certainly increase the attractiveness of a country as a base for international sub-contracting. Tax holidays may be applied, although there is some evidence that they have relatively little effect on investment.

A crucial factor affecting international sub-contracting is the apparent political stability of the government of the sub-contracting country - not for the sake of ideology, but on a practical business level. The main concern of a principal is with security of supply, also the security of any possible investment. If there is believed to be a serious danger of expropriation of foreign-owned factories, firms will avoid any operation with a pay-back period of more than two or three years. Alternatively, principals will adopt a form of business relation with their sub-contractors which limits their own financial risks. In addition, because an interruption to supplies would affect the principal's own factories, it is common for firms to spread their sub-contracting business over a variety of countries, and to have "back-up" or "reserve" production capacity at home. Other dangers to security of supply include the possibility of strikes at the sub-contractor plant, or at the docks; and unpredictable and erratic customs clearance.

Government policies in the developed countries, particularly on tariff and non-tariff barriers to imports, can also affect the scope and direction of international sub-contracting. Items 807.00 and 806.30 of the U.S. Tariff Schedule have been mentioned; the United Kingdom and Japan have similar provisions, but subject to far tighter restrictions on their use. West Germany makes importers pay the effective tariff on the value added abroad. For products where developed country protection is substantial - notably many processed agricultural products, textiles, and clothing - preferential access to a developed country market can weigh heavily in the choice of sub-contracting country. Thus Far Eastern textiles are largely shut out of the E.E.C. by quota, but E.E.C.'s Associated States are exempt from both quotas and duty, so they have access to a heavily protected export market.

Benefits and Dangers for the Developing Country

International sub-contracting vs. direct exports. For the developing countries, an alternative to international sub-contracting is direct exportation. The essential difference is that sub-contracting avoids the problems of marketing: outlets, brand names, publicity, market research, design. In many cases it is possible for exporters to buy most of these marketing services separately. For many products, however, the scale of investment required in overseas marketing facilities may be far beyond the capabilities of most developing countries, particularly where sucessful product differentiation imposes a high initial sales campaign cost on potential new entrants to a market. This would be true for most consumer durables, where effective marketing implies the establishment of a network of after-sales servicing facilities (with the concomitant investment in stocks and warehousing for spare parts). Also, organizations such as Sears Roebuck in the United States or Boots in Britain benefit from large economies of scale in marketing which are related to the total volume of their sales rather than the sales volume for any particular product - economies that it would be very hard for a developing country exporter to duplicate. Closeness to the market is a most important advantage of local firms, either for consumer fashion goods or for industrial products which require technical selling. To overcome its problem of distance from the market, a foreign firm operating on its own may be forced to set up an expensive local office with high-level staff.

International sub-contracting offers a solution to such difficulties. In the case of international sub-contracting of components and processes, direct exportation would often be quite impossible for a developing country. Thus one clear benefit of international sub-contracting is that it permits a developing country access to certain markets which would otherwise not be available. Even where direct exportation is a feasible alternative, international sub-contracting may well enable the developing country to achieve a far faster growth in exports. One reason for this is that it enables production to be guided by strict quality controls based on specific consumer requirements.

Dealing with multinational corporations. An issue much discussed is whether it would be better for developing countries if they could buy separately the items in the multinational corporation package - capital, management, technical know-how, marketing. In this context, international sub-contracting can certainly take a wide variety of forms: one-off orders (e.g. for clothing), long-term contracts, and then varying degrees of technical assistance and capital participation right up to the wholly owned sub-contracting subsidiary of a large foreign firm. Firms may have a stronger or weaker preference for wholly owned subsidiaries: American and British firms seem to have a strong preference for wholly owned subsidiaries while this is much less the case with continental European, Japanese, or Australia firms. Prima facie, there would seem to be grounds for believing that there is more encouragement to local entrepreneurship if the sub-contracting relationship is of the contract rather than the subsidiary form. As against this, in one of the closer forms of business relationship the principal is more likely to provide technical assistance. Also, subsidiaries of multinational corporations can bring to a developing country resources of management skills and of risk capital which would not otherwise be available.

It is often argued that it is inherently risky for a country to be dependent on the subsidiaries of multinational corporations for production and exports: that corporate executives may suddenly decide to reshape production and export systems. However, dependence - with all the risk that it inevitably entails - may be as critical a problem with "arms length" contracts as with wholly owned subsidiaries of multinational corporations. Just as a multinational corporation can switch its sub-contracting business from a Taiwan to a Korean subsidiary, so also it can switch its "arms length" contracts - indeed, with contracts the switch is easier, since the multinational corporation is not directly responsible for the people it throws out of work by the shift. In a volatile political situation, the principal may well prefer a contract relationship - less financial risk and commitment for the principal, but by the same token less assurance of future work for the sub-contracting country. Furthermore, one may well wonder how independent a sub-contractor with one or two dominant clients really is; in practice, the principal under such circumstances may be able effectively to control the sub-contracting firm, whether or not it has any share of the equity capital. With so many different situations possible and so many considerations involved, there is probably no form of business relationship which is always better, or always worse, than any other from the point of view of either the developing country or the foreign firm.

One industry, vehicles, illustrates particularly well the problems of a developing country in fostering industrialization, engaging in international sub-contracting, and dealing with the multinationals. Because of the economies of scale which arise, an attempt to increase local content per vehicle by import-substitution normally leads to a steep rise in costs for technical production reasons. Yugoslavia, Brazil, Mexico and India have a reasonable-sized vehicle market, but for the average developing country low population and low GNP per capita produce tiny markets. In such circumstances, once one goes much beyond basic assembly the technical diseconomies of further import substitution become very substantial. The new practice is to continue imports, but to export certain parts for the entire world market of a particular model: Yugoslavia and Spain make certain parts for the entire Fiat world market; Mexico and Iran will be doing the same for an American firm. These examples exist; but it is not easy to find suitable parts. The best possibilities for international sub-contracting in the vehicle industry are probably spare parts for obsolete models (which Brazil has exported to the United States for some years), and tiny minor fixtures - typically presswork - which the vehicle companies have always bought in anyway.

International sub-contracting by vehicle firms is certainly becoming more common. Berliet, Citröen, and even General Motors have recently sent buyer teams around to potential sub-contractors in Morocco, partly in response to local pressure. Pressing the multinational vehicle firms for international sub-contracting business may be a good enough strategy, but can be taken too far: at the extreme, a multinational corporation may be prepared to buy any part, at any price, and will simply weight the cost of the Completely Knocked Down vehicle packs it sells to make up for any loss. The developing country is then in a barter situation (i. e., selling parts and buying CKD vehicles in an exchange with the same firm) as with bilateral account trading.

Competition between developing countries for sub-contracting work. With the multinational corporations able to shop around throughout the developing world, one danger which has provoked quite some discussion is that developing countries will compete with each other for international sub-contracting work to such an extent that even the winners in this competition obtain little net benefit. There is probably some justification for this view. Already there is a tendency among developing countries to compete over the length and scope of tax holidays. There is also a trend to provide "ready-made" industrial estates, and often subsidized credit. These estates are probably rather effective as means of attracting international sub-contracting work. The returns to the economy may justify the provision of a certain amount of infrastructure, both items such as power and telephone lines and also perhaps technical training facilities. Subsidized credit and tax holidays are more difficult to defend; it is rather paradoxical for capital-scarce countries to be providing cheap capital to large corporations based in capital-rich countries. More and more developing countries are also instituting export subsidies, or are contemplating doing so; bonus exchange rates are virtually equivalent. Export subsidies can no doubt have an effect in attracting international sub-contracting work, but do involve a variety of dangers; at the extreme, a country can find itself exporting at a foreign exchange loss. Just as overprotection of import substitution is possible (and frequently practiced), so also is overprotection of exporting possible. Korea, with its rapid export growth on the basis of concessional credit, may be getting into this type of difficulty.

In order to maximize its economic gains from industrialization, the strategy of a developing country interested in attracting sub-contracting work should be very different from that which many aspirants are following at present. First of all, the country should consider whether its labor costs and location make it a feasible candidate: many countries would probably find it most difficult to attract international sub-contracting whatever policies they pursued. If international sub-contracting does appear to be a real possibility, the country should avoid overvaluation of its currency, or a legal minimum wage greatly in excess of the scarcity value of labor, and should cultivate a reputation for "stability." Above all, it should remove bureaucratic obstacles to importation, exportation, and setting up a factory. Cutting red tape may be much cheaper, and much more effective, than grandiose concessions available after two years' negotiation. Once disincentives have been eliminated, the country can examine how far it is necessary or desirable to offer positive incentives. It should then choose the most cost-effective package, and the one that creates the least economic distortions; this is unlikely for example to include long tax holidays or extensive subsidized credit.

The reliability of sub-contracting demand. One of the most frequently mentioned fears about demand for international sub-contracting is that it will suddenly evaporate, causing distress and economic dislocation in the developing country. If a sudden excess of demand in, say, Europe, has come up against limited capacity, then sub-contracting demand may suddenly become large in Portugal or Morocco, but subsequently disappear as new capacity is installed nearer to the center of consumption. On the other hand, if there are more fundamental economic reasons for the sub-contracting demand - for example labor-intensity of the production process - then it is much less likely that demand for sub-contracting will appear and then later vanish. On the whole, it is all too likely that wage differentials, at least in absolute terms, will tend to increase between the developed and developing countries, so that the economic forces behind the move to international sub-contracting will become stronger. As against this, unions in developed countries may sometimes be successful in ensuring that, in a recession, the workers sacrificed are those in the developing country. However, General Instrument Corporation now has 12,000 workers in Taiwan, more than in all its American operations combined: they presumably would be unlikely to sacrifice their Taiwan operation for one in the United States. As time goes by more and more firms will come to have a substantial stake in sub-contracting production in developing countries, and accordingly one would expect them to be increasingly reluctant to jeopardize it.

In theory, it is true, sub-contracting demand could move on from one developing country to others with still lower wages. Over, say, twenty years, this may well actually occur, as wage rates rise: the original sub-contracting country will grade up in its international comparative advantage, as Hong Kong has done, producing and exporting increasingly skill-intensive products. This should cause no great difficulties - no worse than the usual structural problems of development. Indeed, a government may be positively anxious to speed the transition to higher-skill work: Singapore no longer encourages firms to set up plants for low-skill sub-contracting. Sudden disappearance of sub-contracting demand as it shifts to another country is not on the whole very likely, because of the forces of inertia and the tangible and intangible investments involved. This is clearly so if a firm has a sub-contracting subsidiary - if it has made the necessary arrangements with the authorities, found land, built a factory. It is probably also substantially true where there is no visible investment but when a sub-contractor has been found, quality control and delivery problems have been solved, and a logistical network established. An industry may be 'foot-loose' or 'run-away' as between the U. S. and a developing country, with a possible ratio in comparative wages of up to 20:1, but not as between two developing countries when the possible wage differential is much smaller and the importance of the wage bill in total costs is much reduced.

A more serious danger to the stability of international sub-contracting demand may be technical progress. For example, the weaving of electronic memories may disappear as ferrites are replaced by integrated circuits; and card-punching may disappear as data is fed directly into computers. A generalized answer to the effects of technical progress is impossible; it would vary from product to product. Garment-making seems particularly safe from this point of view. Also, one should almost certainly not regard technical progress as an independent factor: for example, if international sub-contracting permits some type of labor-intensive assembly work to be done cheaply, there will be rather little incentive to devise automatic machinery for that process. Furthermore, if an international electronics firm has found a successful sub-contracting partner or established its own overseas subsidiary, it is unlikely to close down sub-contracting operations because of technical change in one process or product. Instead it will try to switch workers from, say, electronic memories to the assembly of other items - say micro-wave radio equipment, special assembly control panels, or non-standard switchboards.

Effects on general economic development. It would be a mistake to concentrate only on the possible dangers of international sub-contracting, and ignore its most obvious potential benefits. International sub-contracting is a direct source of foreign exchange. It also provides industrial employment at low capital cost per worker, and - unless the government is overgenerous in its concessions to the multinationals - most of the capital required comes from abroad, and would not otherwise be available. Lack of jobs is likely to be the largest single source of social and political disruption in the developing world in the next two or three decades.

It must be admitted that international sub-contracting may heighten the problems of regional imbalance in development. Sub-contracting will tend to concentrate in existing major industrial centers (e. g. Casablanca in Morocco), or possibly in a special Free Trade Zone. But the creation of a Free Trade Zone in a backward region of the country, with the aim of achieving regional balance, may simply fail to attract clients - unless at the same time extremely good shipping and communications facilities are provided. Especially if wages are fixed at a high level for political reasons, international sub-contracting operations could be a honeypot to attract labor off the land, and in this way create more unemployment than they eliminate. There is some danger that the Mexican border strip will have this effect. If, as is now proposed, manufacture in bond is extended to the rest of Mexico, that could greatly assist in avoiding this danger.

Perhaps the most interesting and difficult question of all is how important are the "spread" effects of international sub-contracting. Here the effects are likely to vary according to the technical type of sub-contracting involved. On the whole, sub-contracting of single processes is likely to have the least spread effects, and certain operations of this type seem naturally to be of an enclave nature. For example, the assembly of semi-conductors in a developing country is rather unlikely to lead on to fabrication of the wafers, by direct backward linkage. However, Taiwan started off with semi-conductor assembly, and will soon be manufacturing television sets for the world market (not just assembly). Also, there have in fact been several cases of backward linkage in Taiwan: production of rayon and polyester for textiles, plastic film for electronics. Whether or not international sub-contracting leads to generalized development depends not only on the type of product but also on the institutional structure of the country concerned, and the inherent skills of the population. Once a multinational corporation has begun to sub-contract certain operations in a particular developing country, it is more likely to sub-contract other ones, as the perceived risk diminishes. A country can slowly raise the skill level of the labor-intensive operations which it performs, from sewing garments to the production of scientific instruments or photographic equipment - making lenses is particularly labor-intensive. Sub-contracting in a developing country may also offer the quality control advantage that 100 percent inspection and testing become economically feasible. Even with the most 'enclave' type of sub-contracting, there are some benefits from the training of an industrial labor force. There is some limited evidence that local value-added tends to rise in relation to gross value: as Table 1 shows, for the developing countries as a whole, the ratio of dutiable value to gross value for U. S. Item 806. 30 and 807. 00 imports has risen in every year since 1967. Of the five major sub-contracting countries, it has risen every year since 1966 in Taiwan, and in all five countries it has risen since 1970.

Nevertheless, except conceivably for a few small countries heavily dependent on foreign trade, international sub-contracting is unlikely to prove the new panacea for economic development. In Mexico, Taiwan, and Korea, where international sub-contracting has the greatest importance, the gross value of international sub-contracting exports has only reached 5-15 percent of the total value of exports. Of course, international sub-contracting on a large scale only dates from about 1965, and is growing fast, so that it is quite possible that in some countries in the future international sub-contracting will exceed its present importance relative to the total economy in Mexico, Taiwan, and Korea.

Economic and Political Effects Within Developed Countries

There have been lurid accounts in the American union press of the enormous profits made by companies which have started up off-shore operations; and no doubt some of the first companies to adopt this particular production innovation did do extremely well. But unless a particular market is very tightly cartelized, this must be a temporary situation. As the use of off-shore facilities becomes generalized, prices either come down, or fail to go up with inflation: this has clearly happened in the case of integrated electronic circuits (where the price for one common type of circuit fell from U. S. $0. 70 to $0. 14 in a year). Thus on the whole the consumers in the developed countries do stand to benefit from international sub-contracting. However, consumers do not usually constitute a powerful political lobby in most developed countries: they are typically much weaker politically, much less well informed, and much less organized than the producers, be they employers or employed.

It is here that one finds one of the most important political differences between international sub-contracting by producer firms and direct exportation of manufactures by developing countries. With direct exporting, both firms and unions in the developed country will lobby against the imports. However, with international sub-contracting by producer firms, only the unions will lobby seriously against imports, for the obvious reason that the firms will be benefiting from the trade themselves. This no doubt helps to explain why, despite political resistance, it has been possible for imports to take over nearly all the United States market for many consumer electronic products, whereas much more limited penetration of the United States textiles market (less than 15 percent of consumption of cotton textiles) led to official 'voluntary' quotas on cotton textiles.

[Extracted from Oxford Economic Papers, Vol. 27, No. 1, March 1975, pp. 95-131. Copyright ©, Oxford University Press, London, England.]

☆ U. S. GOVERNMENT PRINTING OFFICE : 1976 210-902/5

DEVELOPMENT DIGEST

A quarterly journal of excerpts, summaries, and reprints
of current materials on economic and social development

CFTR[illegible] [illegible]RY
MYSO[illegible]
- 8 [illegible]

Gordon Donald, Editor; Donna U. Vogt, Associate Editor;
Renee D. Sumby, Digest Secretary
Prepared by the National Planning Association

for

Agency for International Development, U.S. Department of State

CONTENTS

Volume XIV - Number 4 October 1976

MOTIVATION AND FAMILY PLANNING 3
Freya O. Bicknell and Diana C. Walsh

THE PROFAMILIA RURAL FAMILY PLANNING PROGRAM IN COLOMBIA 9
Gonzalo Echeverry

VILLAGE FAMILY PLANNING - THE INDONESIAN MODEL 17
Haryono Suyono, S. Hartati Pandi, Ida Bagus Astawa, Moeljono and Thomas Reese

CHINA'S EXPERIENCE WITH MOTIVATION FOR FAMILY PLANNING 25
Leo A. Orleans

POPULATION POLICY AND RESEARCH 32
Ronald G. Ridker

HOUSING FINANCE

HOUSING FINANCE TO MEET CHANGING CONDITIONS 51
Robert H. Freed

SAVINGS AND LOAN SOCIETIES FOR LOW-INCOME URBAN FAMILIES 56
Georges Vernez

HOUSING AND SOCIAL SECURITY IN LATIN AMERICA 61
Morris L. Sweet and S. George Walters

INDUSTRIAL TECHNOLOGY

Industrial Technology in Developing Countries: An Editorial Introduction 69
Gordon Donald

ECONOMIC MAN AND ENGINEERING MAN 71
Louis T. Wells, Jr.

FACTOR PROPORTIONS FOR MANUFACTURING IN LESS DEVELOPED COUNTRIES: A SURVEY OF THE EVIDENCE 71
Lawrence J. White

POLICIES TO ENCOURAGE THE USE OF INTERMEDIATE TECHNOLOGY 94
Howard Pack

REORGANIZATION OF TOOL AND SMALL MACHINE PRODUCTION WITH COOPERATIVES IN SRI LANKA 109
D. L. O. Mendis

ENTREPRENEURSHIP AND THE PROMOTION OF NEW LOW-COST TECHNOLOGY 116
Nicolas Jequier

(Unless otherwise indicated
currency is expressed in U. S. dollars.)

FAMILY PLANNING MOTIVATION

MIDWIFE EMPLOYED BY
NATIONAL FAMILY PLANNING COORDINATING
BOARD OF INDONESIA EXPLAINS
INTRA-UTERINE DEVICE TO VILLAGE WOMEN
IN BALI (Photo: United Nations)

Motivation and Family Planning

Freya O. Bicknell and
Diana Chapman Walsh

[A key problem for family planning programs is the motivation of couples to accept the contraceptive services offered and to sustain the practice of family planning. Too often the manner of presentation of such services is flawed by cultural insensitivities and communication barriers which create unnecessary obstacles to acceptance, requiring high levels of motivation. New delivery systems such as community services could overcome many of these obstacles]

So much has been said about rapid population growth that the facts are losing much of their impact. We know that the world's population currently stands at about 4 billion, that it is growing at a rate of over two percent annually which means that 75-80 million people are being added every year, and that it will double in about 35 years. We know that rapid population growth has a built-in momentum because patterns of high fertility are not easily reversed, and because even if they were the large numbers of babies born today will swell the ranks of potential parents in the generation to come. And we know that rapid population growth is a multiplier of other problems - problems for families, for nations and the international community. But the gap between possession of this disquieting knowledge and effective action plans is wide and deep.

Those who are working to bridge this gap frequently pinpoint motivation as the core of the problem for family planning programs at their present stages of development. A review of the literature, and the experiences of the Pathfinder Fund in developing countries, suggest that a different approach to some of the accepted methods for instilling motivation might improve the prospects

Ms. Bicknell is Director of information, education and communication of The Pathfinder Fund, Boston, Mass. and Ms. Walsh is Senior Program Associate in the Massachusetts Dept. of Public Health.

for family planning programs in the future. This different perspective would demand changes not on the part of the potential client so much as in the delivery system itself. Many programs have inadvertently incorporated unnecessary, often formidable bureaucratic, physical, economic and psychic disincentives in their structures. This paper will contend that delivery systems can and should be designed to reduce the amount of motivation currently required of potential new adopters.

Discussions of family planning information and education efforts commonly place them within a framework of stages in the development of programs. The stages proceed roughly as follows: Initially, a family planning group seeks to stimulate interest among the leadership of a country in population programs. When sufficient legitimacy has been won, clinical services are opened, usually first a few sites in an urban center under the aegis of a private family planning association, later in a government program administered through the existing health infrastructure. After a "clinic era" of several years' duration, the emphasis usually shifts to a field approach, characterized by more vigorous efforts to reach potential acceptors instead of waiting for them to take the initiative. Ultimately the existing demand for services appears to be met, and the number of new acceptors begins to reach a plateau and then may taper off. At this latter stage the challenge is to devise tactics and messages that will persuade as well as inform; the problem becomes motivational, and the primary onus rests with information campaigns.

How is this task of persuasion to be accomplished? To date, the predominant solution has been to deploy a cadre of "motivators" - paid or volunteer field workers engaged in face-to-face promotion of the concept and facts of family planning among individuals and groups. They are combined with at least some clinical services and often complemented by other communication strategies, including the mass media. It is not uncommon for field workers to constitute, in their salary and training costs, the largest single item in a national family planning budget. In the successful Asian programs in Korea, Taiwan, and Hong Kong field workers are credited with the direct or indirect motivation of the majority of acceptors.

Organizationally, motivator programs vary widely. In addition to trained social workers, the quasi-professional or lay motivators typically come from groups such as midwives, community leaders, housewives and satisfied users, teachers, merchants and traveling salespeople. Research evidence suggests that motivators are most effective when they are indigenous to the areas where they are working, that their effectiveness attenuates over both distance and time because they exhaust their sphere of personal contacts. Older field workers who are married, have children, and themselves have experience with contraception seem to be most successful. Their remuneration can take the form of a salary with or without bonuses, a per-acceptor incentive, or can be nonexistent; strictly volunteer efforts, however, appear to do least well. Training ranges from about three weeks of intensive instruction in the highly organized programs to none whatever; and supervision, almost always a problem to some degree, also varies in extent and success. Home visits or group meetings can be stressed, or a combination of the two. On balance, home visits appear to be preferred.

There is little doubt that motivators can be quite effective in recruiting new adopters. A motivator can supply a form of personal communication on an intimate subject which the clinic cannot. A less obvious disadvantage of the motivator approach is an assumption underlying it: the belief that a shortage or lack of "motivation" among women in developing countries accounts fully for acceptance plateaus, and that this missing ingredient can and should be inculcated by outside agents. Sometimes there is confusion between motivation in the sense of a person's having a motive or desire, and "motivation" meaning the act of creating a motive in another person by persuasion. Too often the woman is assumed to be out there waiting with a desperate "need" for family planning if someone will only tell her about contraception, where it can be obtained, and possibly quell some slight fears or resistance. In fact, however, the woman's need is not necessarily a desire, nor is it absolute or unequivocal. If she already has some interest in spacing or limiting children, she may have some desire of indeterminate strength to get contraceptive assistance. But whether or not she will avail herself of an opportunity, and whether she will continue a method after her initial adoption decision, will depend on a number of factors both internal and external to the woman herself: the strength of her motivation (increased or perhaps made more explicit by the motivator) as against various factors of resistance, which might include cultural proscriptions against using contraception or frightening rumors about danger to her health, a distaste for interfering with the sex act, discomfort caused by the IUD when in place or problems remembering to take pills, and the disincentives which make it difficult to reach a clinic or difficult, unpleasant or costly to be served when there. An emphasis on "motivation" is misleading insofar as it oversimplifies this complicated interaction of individual feelings and reproductive decisions.

The task of persuasion is much more difficult where women have no desire for family limitation. It is generally acknowledged that high fertility in less developed countries derives from three basic perceptions: 1) that children have economic value because they share the burden of family labor, particularly in rural areas; 2) that they will serve as "social security" in their parents' old age; and 3) that they enhance their parents' prestige - a man's virility, a women's very raison d'etre. Often these perceptions are firmly rooted in reality. Under such conditions, effective fertility regulation is two long steps from realization: first, the basic desire to space, limit, or stop childbearing is needed; second, from that initial desire, the impetus is needed to seek out an effective means of contraception and, with most methods, to use it continuously. The "motivator" is faced with a formidable task.

An alternative orientation is to reverse the perspective: instead of concentration on trying to increase the motivations of potential acceptors, we should ask whether there isn't some way to build from already existing motives by making the service more accessible, so that those who are only moderately interested will not be discouraged before they succeed in obtaining contraceptives. The lower the level of motivation needed, the more the potential acceptors. It has long been recognized that the more traditional methods (condoms, foam, the diaphragm, withdrawal, rhythm) require considerable and sustained personal motivation; the IUD and the pill, though not connected with the sex act also require commitment; and research is underway to find improved devices. But it is less common to look at delivery systems to see not only what they offer their potential clients, but what they ask in return. Existing programs frequently demand a higher level of personal motivation from clients than is either reasonable ornecessary.

Unnecessary obstacles to the practice of family planning result from cultural insensitivites and communication failures on the part of family planning programs. For example, family planning professionals have adopted language which often leads to misunderstanding, discomfort, and suspicion. Within the United States, Kanter and Zelnick interviewed a group of urban black women, found serious confusion about family planning terminology and concluded the "family planning, that nice middle class term --- doesn't convey the message that is intended." Epitomizing the verbal confusion they found, they cited a woman who spoke repeatedly of having her "coils tied." With evidence that American family planning language fails to communicate clearly among American audiences, it is hardly surprising that the export to developing countries of "modern family planning" - originated in Europe and North America and bearing Western, medically-rooted labels - often eventuates in ambiguity and perplexity.

The messages advanced by sponsors of family planning programs are often transplanted from one culture to another without being adequately pretested. For example, the appropriateness of the theme "responsible parenthood," widely adopted in Latin American countries, can be questioned on grounds that irresponsible parenthood implies an insult to those who do not participate in the family planning program. Messages encouraging couples to have the number of children they can afford take on cruel connotations in areas where many live life at the subsistence level, and can truly afford no children. Rogers points out that the association of oral contraceptives with curative medicine, based on the words used for them in most languages, unnecessarily complicates the way in which "the pill" is perceived (as a remedy for sickness) and contributes materially to high rates of discontinuance among pill users.

An inadequate appreciation on the part of program planners of the full limitations implied by illiteracy gives rise to additional subtle obstacles. Abstractions in general, as well as pictorial symbols and film making devices, can be misleading and distracting to an audience unaccustomed to them. The medium does become the message in this case, quite literally the entire message, obscuring totally its content. The message needs to be adequate and understandable but not excessively technical or detailed. Some of the most effective communication with illiterate and semi-illiterate audiences is done by analogy. Glaessel and Stycos describe the talk used in the Dominican Republic family planning program, where a simple dramatic gesture - closing the door and commenting that this is the way to keep the burglar out - replaces the confusing illustration of a diaphragm covering a cervix; where a birth control pill is dropped into a glass of water and shown to dissolve in order to counter the common fear that pills will accumulate in the body; or where an IUD is likened to a new pair of shoes, perhaps uncomfortable at first, but soon a part of oneself. Teaching methods such as these succeed because they translate the basic facts of family planning into the vernacular of ordinary experience. They are developed easily and naturally by people who are intimately familiar with the day-to-day lives of their audiences. But designers of family planning messages who are removed from the people they are trying to reach, and who operate at a high level of abstraction, run the risk of falling into the trap of pretesting a message for the field by showing it around the office.

Finally, and unfortunately, a catalogue of the obstacles needlessly barring access to family planning requires mention of the indignities and cruelty frequently visited on uneducated women by the purveyors of modern medicine. Mernissi's survey of sixty women in urban Morocco, for example, uncovered a pattern of humiliation affecting by association the family planning service situated in the hospital. One woman described vividly the eight hour wait:

> You have to wake up in the middle of the night. We start lining up at the gate of the hospital before dawn, around four o'clock. It is not that bad in the summer and spring, but when it is cold and rainy, it is not very pleasant. By eight, if you are lucky, you will get a ticket. Then you have to run home to wake up the child, feed him, dress him and run back to start a new line, this time inside the hospital courtyard. Sometimes you line up until 12:00 and you are told that you ought to come back another time.

The nurses are described as impatient and unsympathetic. They ridicule women who mispronounce medical terms and, in the words of another of the women interviewed, "you feel the floor crumble away under your feet." Women waiting for gynecological exams are required to undress before going into the doctor's office so as not to waste his time: "You take off your pants in the hall and sit there waiting. There are drafts of cold air, people walking by. You feel inhuman." In the best of circumstances, most women dread visits to the gynecologist or his equivalent.

If some of the unnecessary and bureaucratic barriers to family planning can be removed, the result should be at least some reduction in the intensity of motivation required of new adopters. To reach those who are less highly motivated, a program must have a pleasant accessible service, appropriate language and, to the extent possible, contrceptive methods which are culturally compatible, and easily used. Several important modifications and expansions of the motivator approach described earlier hold some promise of fulfilling these requirements. For example, test demonstrations are completed or under way in a number of countries in Asia, Africa and Latin America using nurses, midwives, and auxiliaries to prescribe oral contraceptives and insert IUDs. Nonclinical or community-based distribution of oral contraceptives is being initiated in some of these countres. In such programs, the motivator also assumes the role of distributor or seller of contraceptive supplies and thus receives instant and direct feedback on the effectiveness of her sales pitch; prospective customers either purchase the supplies or they don't.

On example of the community distribution design is the Profamilia program in Colombia, described in the next article. A 1973 Ford Foundation-sponsored evaluation of this rural Profamilia program was highly favorable; and the first results of a current Pathfinder evaluation of the urban Profamilia program also look extremely encouraging. Instead of reliance on social workers representing a totally alien way of life, community women themselves are now doing the information and education work with their friends and neighbors. The women are enthusiastic and committed; the numbers of adopters have been impressive, and the cost per acceptor low. The Indonesian program described in a following article also illustrates the value of this general approach.

Community distribution programs, and the diversification they represent, look like the way of the future for family planning. It is clear that diversification is badly needed: an expansion and a broadening of thinking in program strategies, in communication channels used, in fertility control methods offered, in the range of organizations involved and government policies adopted. Community distribution seems to provide for that rare and salutary confluence of local resources and capabilities with real community needs that brings benefits to all: development for the community, personal growth for the contraceptive distributors and, for their friends and neighbors, a chance of improving the quality of life. This, after all, is what family planning is all about.

[Adapted from an adress to the Symposium on Family Health, Liverpool School of Tropical Medicine, April 1975.]

The Profamilia Rural Family Planning Program in Colombia

Gonzalo Echeverry, M. D.

[The Profamilia program in Colombia has been organizing family planning services at the community level in rural areas in conjunction with an existing developmental structure. Field workers train local leaders to advise on birth control matters and distribute contraceptives.]

Profamilia, a private family planning organization, has been providing services in the major urban areas of Colombia since 1966. Until 1970, however, Colombia's large rural population lacked access to family planning information and services at the local community level. This program is exceptional in working with an agricultural organization in its educational and motivational efforts, and in dispensing oral contraceptives through lay volunteers without direct medical supervision.

In 1970 Profamilia solicited the assistance of the National Federation of Coffee Growers in setting up a family planning program on an experimental basis in a few select rural areas in the state of Risaralda. Gradually services were extended to many other rural areas throughout the state and, after two years, to other states. By 1974, there were 370 rural distribution posts dispensing contraceptives in six states, and about 12,400 women had registered with the program.

The Experimental Program

Approximately 40 percent of the population of Colombia, or about 9 million persons, live in

Dr. Echeverry is director of planning and development in Profamilia, Bogota, Colombia.

veredas, small, rural agricultural communities. They are relatively isolated, their only contact with life outside their vereda generally being a weekly visit to the market in the neighboring small town. The veredas have no public health services, and prior to the Profamilia Rural Family Planning Program few people had any access to family planning information or services. The average rural family is much larger than its urban counterpart. Sample surveys conducted prior to initiating the rural family planning program showed an average of seven children in the families interviewed, whereas the number of children the respondents said they wanted and considered ideal averaged 3.4.

On the basis of their investigations, it seemed clear to the directors of Profamilia that there was a need for family planning services in rural Colombia. Preliminary planning sessions were initiated in conjunction with the National Federation of Coffee Growers (FNC), which has an extensive network of rural extension agencies that assist coffee-growing communities in various ways. The rural extension personnel of FNC teach the people how to grow coffee and care for the plantations, educate them about nutrition and home economics, teach handicrafts, organize community activities, and organize social clubs for men, women, and youths.

There was no precedent for such a program in Latin America, and neither FNC nor Profamilia had any experience in this field They believed, however, that they had both the necessary organizational structure and sufficient knowledge of techniques to establish a pilot study in a small, clearly defined area. With the experience gained there, the project later could be extended to the rest of the country.

In November 1970 an experimental rural family planning program was set up in the Department of Risaralda, operated jointly by Profamilia and the Coffee Growers Committee of the Department. The experiment continued for two years before being extended to other areas. From it were developed the methods of communication, motivation, distribution, registration, and follow-up used in other Departments.

The Profamilia Rural Family Planning Program is based on the following principles:

1. Although contraceptive distribution posts have been set up in many small cabeceras (equivalent to a county seat) that lacked family planning services, the primary focus of the program is the vereda. Therefore, the program is essentially centrifugal, that is, it takes family planning information and services to the immediate community and into the home instead of requiring the people to come to a distant center or clinic to receive information and services.

2. The women responsible for communication and motivation (field workers) come from the same rural area and resemble as much as possible the people they serve. They speak the same language have the same customs and traditions, and can move through the community without being regarded as intruders or outsiders.

3. The family planning methods offered are those that can be dispensed without medical supervision, because medical personnel and facilities are very few in rural Colombia. For this reason, the program offers condoms and spermicides but not IUDs. It was decided, however, to also offer oral contraceptives. This decision, which runs counter to the thinking of some, was made because (a) excluding the IUD, the pill is the most effective means of birth control; (b) the medical risk it carries is smaller than the risks of pregnancy and childbirth; and (c) any woman experiencing side effects can always be referred to a physician at the nearest Profamilia clinic or health center.

4. Contraceptives are distributed in each participating vereda by a volunteer who is selected from among the natural "leaders" in the community. Because they are known and respected, the distributors are better able than outsiders to elicit the cooperation of the community. In addition, because distributors reside in the immediate area, participants in the program do not have to wait for the field worker's next visit to purchase contraceptives.

5. The existing FNC infrastructure in the vereda is used by the program so that parallel structures do not have to be created and efforts duplicated. The personnel and educational programs of the agricultural extension agencies are used to promote the idea of family planning. Because the people place great trust in these agencies, their influence is important to the success of the program.

6. Systems of registration, record-keeping, and administration comply with technical standards and conventions. At the same time, they have been simplified as much as possible so that they can be correctly carried out by the field workers and by the community volunteers. Record-keeping procedures must allow automatic and permanent evaluation of those who join the program, the length of time a method of contraception is used, the number of people transferring from one area to another, and the total number of cases lost to the program.

7. The basis of the program is education, and its success rests on the thoroughness with which the people are convinced of the benefits of family planning and understand the different methods. Only then will acceptors be motivated to continue to practice family planning on their own.

8. The family planning program is part of a wider plan of assistance, which is called "integrated rural development," and is not regarded as an end in itself.

Organizational Structure of the Program

The program is organized around three geographical units. In ascending order, they are the vereda, the county, and the work zone. The number of veredas in a county varies greatly - some have fewer than 25 and others have more than 85. A work zone consists of up to ten contiguous counties. There are four levels of personnel within the program. Each vereda in which the program operates has one distributor. Each field worker is in charge of ten veredas. For every five field workers, there is a field supervisor; and for every ten field workers and two field supervisors, there is a zone director.

Selection and Training of Field Workers. In terms of personnel, the basic unit is the female field worker, who is a full-time employee of Profamilia. She must meet the following requirements: have lived in the municipality in which she is going to work for at least five years; be at least 20 years old; preferably be married; and have at least two years of secondary education.

When a zone is being organized, at least two suitable candidates for the position of field worker are chosen from each county in the zone. They attend a one-week course in which they are introduced to the basic aspects of the program. Each candidate is given a small grant to cover her expenses. At the end of the course, the final selections (one field worker for every ten veredas) are made on the basis of a personal evaluation. The rest of the participants are considered substitutes and are called upon in the future if needed. Whenever possible, more than two candidates are trained from each county, not only to keep a number of trained people in reserve but because it has been seen that those who have received the training tend to voluntarily motivate women in their own communities to practice family planning.

Selected candidates then go on to a second phase of training in the field. They are divided into groups and, under a supervisor's direction, they hold community meetings within the veredas in the work zone. This phase lasts at least two weeks, with daily meetings for self-evaluation of the trainees. At the end of this phase each field worker begins work in her assigned area under the direction of a supervisor. Every two weeks, the field workers under each supervisor meet to evaluate their work and resolve any problems that have arisen. After a month, all the field workers and their supervisors meet with the zone director for lectures and to discuss the program and its results. Various administrative matters are also discussed, such as salaries, monthly reports, the supply of materials and necessary forms, and so on.

For every ten field workers in a work zone there is a zone director, who may be male or female. Each director is provided with a vehicle and regularly visits the villages in the county to supervise the field workers, suggest possible improvements in their work, and help them resolve any difficulties. The zone director also collects data and records in the area for which he or she is responsible.

Operation of the Program

Once a county has been chosen for the introduction of the program, the field worker's first task is to contact the rural extension personnel of the local Coffee Growers Committee and gather as much information as possible about the veredas in the county, community leaders, and the existence of housewives' and "friendship" groups, young farmers' associations, and any other social or cultural clubs. The field worker is then in a position to carry out an investigation on a sample of the population to determine their knowledge of and attitude toward family planning. This is not a conventional KAP study but an interview with a simple questionnaire. The inquiry collects information on age, education, desired number of children, knowledge of contraceptive methods, methods used, and interest in obtaining information and supplies. Using information gained from the rural extension agencies and the survey, veredas are selected for introduction of the program and methods of communication and education are chosen.

The first approach to the community as a whole is usually through open meetings, preferably organized by the rural extension agencies. The field worker explains the existence of the program, the importance of family planning, and the intention to establish the service in the village. The reaction observed at these initial meetings is an important pointer to the way in which the campaign of information and motivation should be conducted. It is important that the first group discussion cover subjects other than family planning - for instance, nutrition, the local economy, and, in a general way, what is needed to develop the area. Most rural people in Colombia do not respond well to a direct approach on the subject of contraception, and it must be introduced cautiously via other, less controversial, topics. For this reason the field workers work closely with the rural extension agencies and take a very active part in the courses (sewing, cooking, manual arts, nutrition, and others) that these organizations run for women, men and young people of both sexes.

When the family planning message is taken up it must be clear, concise, concrete, and simple. It has been our experience that these people are interested in all matters that have a direct bearing on their lives but have little if any interest in the demography of their country or the continent. Care must be taken, however, not to disturb their traditions or religious beliefs, hence, the importance of using local people as motivators. By emphasizing the relevance of family planning to their lives, the field worker can increase interest in and lower resistance to the program. Once contact with the community has been established through such meetings, the field worker can form a more personal relationship with the families through home visits, during which she will try to help them with their particular domestic problems. Gradually, the subject of family planning can be introduced in more depth.

Films and folk drama have been especially effective means of communication in rural areas. Attendance at meetings is much higher when a movie is advertised. Preferably the film should concern rural development or family planning, but any film is good as a draw in rural regions. Folk theater in the form of short social dramas on family planning, written and acted by the field workers and members of the community, is an excellent means of attracting attention and of putting across the message, with the additional advantage of being a stimulating amusement that encourages creative activity in the village. Illustrated pamphlets and wall charts also have proven to be effective ways of communicating the family planning message.

Distribution posts. The field worker's next task is to find a man or woman in the vereda who will assume responsibility for distributing contraceptives and keeping certain records. Sometimes this step is taken while the initial educational phase of the program is still going on. The decision to begin actual services is made by the field worker on the basis of the particular circumstances obtaining in the vereda.

Almost always, someone regarded as a leader in the village will be suggested by the local people as the best person for this job, and, indeed, someone who is already respected and trusted by the community will have greater influence. If the field worker takes sufficient care in explaining the program and encouraging this person (usually a woman), she will generally agree to distribute the contraceptives. In those rare cases when she refuses, the field worker chooses someone else who has shown interest or another person suggested by the people. The field worker then gives the distributor careful instructions on the program and her duties, and supplies her with pills, condoms, spermicides, and registration and other forms for recordkeeping. The distribution post is generally in this person's own home or a local store; posts also have been established in schools, rural cooperatives, and even in local police stations.

It is a general principle of Profamilia that anyone benefiting from the program should contribute something, however little, for the service. Therefore, in the rural program contraceptives are sold for a small fee, which is much less than the commercial price. One cycle of pills is four pesos (US$0.16). The distributor keeps half the price in return for her services and turns over the remainder to the field worker. This small income gives her an interest in seeing that women continue to purchase contraceptives. When a woman fails to return for more supplies, the distributor visits her and encourages her to continue.

When a woman first comes to the distributor for contraceptives, the distributor makes out a registration card. This card is prestamped with a code that identifies the distribution post, and with a number, which becomes the identification number of the acceptor. The distributor fills in the date of first acceptance, name of acceptor and spouse, address, acceptor's education, number of children living and dead, number of abortions, age of youngest child, monthly income, and family planning method chosen. These statistics are carefully recorded and used on county and national levels to plan future programs.

At the same time, the acceptor is issued an identification card that, in addition to name, contains the same distribution post code number and acceptor identification number. This card must be presented for the purchase of contraceptives. And the participant is also given a book (carnet) of 24 coupons, each one marked with the distribution post code and her number. With each purchase of a cycle of pills, the distributor tears out a coupon, which she later turns over to the field worker. The coupons serve to indicate the volume of oral contraceptives sold by each post each month and the length of use for each participant. Carnets are not issued for the purchase of condoms and spermicides. These three forms provide the basis of the statistical recordkeeping and follow-up system, and for the administrative and evaluative work at higher levels.

Conclusions

The Profamilia Rural Family Planning Program has now been in existence for about four years. In 1974 there were 370 distribution posts operating in 60 counties of six states, and about 12,400 families had participated in the program. The number of participants in the program suggests that the rural population in Colombia feels a need for family planning services, despite a tradition of opposition.

Profamilia believes that the program has demonstrated that an organized family planning effort is feasible in even very rural areas.

The outline of the program given here shows that it is based, operationally as well as administratively, on the concept of virtually independent modules or work units. Each zone functions separately in providing services and collecting statistics, which are then fed into a central office. This modular structure seems particularly well suited to a rural endeavor which, by necessity in developing countries, will almost always start small. If successful, it can later expand over a large area because it can be applied to and accommodate any size of program without altering the basic organizational and administrative structure.

Manpower and financial constraints have been reduced by using local residents with a minimum of training as motivators and community volunteers as distributors of contraceptives. More importantly, however, it is felt that their dedication, enthusiasm, and cooperation have been indispensible to the success of the program. The experience of participants taking oral contraceptives without direct medical supervision strongly suggests that systematic control of contraceptives by physicians is not indispensable as long as medical attention is available when necessary. This fact, perhaps more than any other, has made family planning services in rural Colombia viable.

[Extracted from "Development of the Profamilia Rural Family Planning Program in Colombia", Studies in Family Planning, Vol. 6, No. 6, June 1975, pp. 142-147. Copyright © The Population Council, New York.]

PROFAMILIA
PUESTO DE INFORMACION
PLANIFICACION
FAMILIAR
PROFAMILIA

LEFT: A Profamilia post in Colombia.

Village Family Planning— The Indonesian Model

Haryono Suyono, S. Hartati Pandi,
Ida Bagus Astawa, Moeljono and
Thomas Reese

[Indonesia has very recently begun a program for bringing family planning services directly to rural villages, which is obtaining unusually high levels of response. Of particular interest is the method of letting different provinces organize their services to fit local cultures.]

The Indonesian National Family Planning Program has evolved through a series of stages designed to make family planning services more widely available while stimulating a movement to institutionalize a small family norm. The goal of the program, contained in the 2nd 5-year plan, is a 50% reduction in the 1970 birth rate by the year 2000. In 1967 the Indonesian Government first became formally associated with family planning when President Subarto signed the World Leaders' Declaration on Population. In 1970, following a period of less formal organization, the Government created the National Family Planning Coordinating Board (BKKBN) in the Ministry of Social Welfare. The BKKBN has its own budget ($15 million for 1975/76) and staff at the provincial and county levels as well as 6,600 fieldworkers.

Initially the BKKBN focused on offering family planning services without cost to users through health clinics on the densely populated islands of Java and Bali. Since 1974 it has expanded its effort to 10 provinces in the Outer Islands. During the initial stage of family planning based on health clinics, an effort was also made to win the support of formal as well as informal community leaders and create a general awareness and support for the program among the

Drs. Suyono, Pandi, Astawa and Moeljono are with the National Family Planning Coordinating Board; Mr. Reese is with AID/Jakarta

the people both in urban and rural areas. Following the acceptance of family planning ideas and concepts at the national and provincial level of govenment the family planning program was extended in early 1975 to villages through the establishment of village contraceptive distribution centers (VCDC) and sub-village family planning groups. This phase is currently underway on Java and Bali, with a goal of establishing at least one VCDC in each village. A next step in the process will be the integration of family planning with other developmental programs at the village level through satisfied acceptors and committed informal leaders.

Program Results

During seven years, the family planning program has increased new acceptors to the program on Java and Bali from 53,103 in 1969 to 1,078,894 in 1972 and 1,785,908 in 1975. Over this period, a total of 6.5 million new acceptors have been recruited on Java and Bali. These results, it should be noted, were achieved largely through the conventional type of family planning program depending on a clinic base, with fieldworkers moving out from the clinics into the villages to motivate couples to seek services at the clinics. In addition, there was some outreach through "Traveling Medical Teams" that move into remote areas in jeeps and vans to offer a variety of family planning services. Only since mid-1975 has village contraceptive resupply been readily available on Java and Bali.

Of interest is the change over time in the methods mix from largely an IUD program in the early years to a pill program. In 1969/70, 55% of new acceptors were using the IUD, and only 27% the pill. By 1975, 68% of the Java and Bali new acceptors were pill acceptors, while only 12% of the new acceptors choose the IUD. In 1975 there was considerable variation of contraceptive selection by province. Bali reported 49% of its new acceptors as having chosen the IUD, while Yogyakarta reported 53% of its new acceptors as choosing the condom. Noteworthy is the fact that the big provinces of West, Central and East Java are predominantly pill provinces, with 83%, 62% and 69% of the new acceptors respectively choosing the pill.

In Table I, incidence and prevalence results of the program through March 1976 are shown, along with the provincial differences in methods of contraception. The cumulative incidence (total new acceptances) ranges from a low of 6.3% in the Outer Islands where the program is quite new to a high of 63% in Bali. In terms of current use, as of March 1976 it is estimated that 4.0% of the married women aged 15-44 (MWRA) are using contraception through the national program in the Outer Islands and 21.2% on Java and Bali, with 32% rates in Bali and East Java.

Table I. Estimated Incidence and Prevalence of Contraceptive Use, March 1976

Province	Cumulative New Acceptors to March 1976 as % of Married Women Aged 15-44	Estimated Current (March 1976) Users as % of Married Women Aged 15-44				
		Pill	IUD	Condom	Other	Total
Jakarta	32.0	5.1	6.4	.9	.4	12.8
West Java	31.0	12.3	1.5	.5	.3	14.6
Central Java	40.6	9.0	6.4	1.3	.2	16.9
Yogyakarta	62.0	3.6	9.7	3.8	.5	17.6
East Java	59.0	20.3	10.3	.9	.2	31.7
Bali	63.0	3.5	26.3	1.6	.6	32.0
Total Java and Bali	46.0	13.1	6.9	1.0	.2	21.2
Total Outer Islands	6.3	2.7	.8	.4	.1	4.0

The characteristics of couples accepting family planning though the national program are of interest. Are these the urban well-to-do, or the rural poor -- those that need the services most, yet can least afford them? In Table II, the characteristics of the family planning acceptors for the 3rd quarter 1975 are listed. These data are from a 10% random sample of new acceptor record cards. It appears that the acceptors from Java and Bali are somewhat different than those from the Outer Island. Acceptors on Java and Bali tend to be younger, have fewer living children, be less well educated and desire fewer children than those on the Outer Islands. The program on Java and Bali tends to be an older, rural one which reaches proportionately more of the poor, while the two-year-old program on the Outer Islands is still relatively urban oriented, with more husbands in government service or trade.

An even more important question is with regard to the impact of the program. Is it, in fact, preventing births? The program is clearly reaching younger women with fewer living children than it originally did. In the 3rd quarter 1971 the median age and parity of an acceptor was 29.5 with 3.8 living children; by 3rd quarter 1975/76, age had fallen to 27.7 and parity to 2.5. This reflects a 6% reduction in age and a 34% reduction in living children of new acceptors over this period.

Unless these couples are substituting private family planning for participation in the national program, or just spacing out a large family, it seems reasonable to assume the program is having some impact on fertility in light of the percentage of estimated contraceptive use. The government is conducting a large three phase intercensal survey with a 250,000 household listing. This survey will go far toward answering many of the questions about the effectiveness of the program, and the reliability of the family planning service statistics system. Preliminary fertility data from a sample vital registration project currently underway in 10 sample kebupatens (counties) of Indonesia indicate that crude birth rates for the period 1974-1975 are well correlated with the percent of MWRA using contraceptives through the national program in these counties. These sample data point in the direction of a relatively rapid reduction of birth rates in those areas where the program has been most active.

Table II. Family Planning Acceptor Characteristics
(3rd Quarter 1975/76)

	Java/Bali	Outer Islands
Average age	27	29
Women under 30	67%	50%
Parity - average number of living children	2.54	3.88
Acceptors with 3 living children who do not desire additional children	40%	28%
Acceptors with less than 6 years of education	52%	30%
Acceptors whose husband is a farmer, laborer, fisherman or unemployed	83%	51%

Reaching Beyond the Clinic

As of 1974, family planning services and contraceptive supplies were available in some 2,500 clinics, free of charge, across Java and Bali. By then it was realized that the program on Java was to be heavily oriented toward the pill and (to a lesser extent) the condom -- both methods that depend upon resupply for effective use. Although the IUD had been promoted vigorously, this clinic-oriented method continued to decline in popularity. From 41% of all acceptances in 1970, the IUD had slipped to 11% of acceptances in 1974. Even though fieldworkers and clinics were paid an incentive to recruit IUD acceptors, the IUD was selected by fewer acceptors, and the incentive has since been abandoned.

During 1974 the dialogue between Jakarta and the Provincial BKKBN's was increased with emphasis on how to maintain program momentum and increase program activity in lagging areas. This "dialectic process" led to the conclusion that an effort had to be made to simplify contraceptive resupply in order to prolong contraceptive use with the pill and the condom. Also, it became evident that the program would have to move out of the clinic if it were to avoid the supposed "plateauing" that has bedeviled other large national family planning programs. In order to attract younger, lower parity women into the program, services would have to be made more convenient, more readily available, and internalized into the way of village life. Accordingly, the family planning program on Java and Bali began to shift out of the clinic. In attempting to move to the villages a few basic concepts have been followed.

First, the BKKBN decided not to standardize or dictate in detail to the six provinces on Java and Bali. Each province was directed to move as quickly as possible to introduce family planning at the village level, but specifics of the approach were left to the provinces in order to harmonize family planning with the cultural nuances of the area. Second, it was decided to move incrementally and focus first on resupply, with emphasis on making it easier for those who had already accepted to obtain contraceptive supplies. Third, it was decided to link the village contraceptive resupply program to a "mother clinic". Contraceptive supplies, with the assistance of the fieldworkers, would flow from the clinics down to the villages, with each village depot linked to a family planning clinic. This would keep the village family planning movement within the clinic's service statistic system so that activities could be monitored, and enable the clinic to exercise control and supervision over village activities. The clinic should be responsive in supporting the village in terms of side effects, questions about supply and so forth. Some methods used in the major provinces were the following.

West Java. Village contraceptive distribution began to be discussed in West Java as early as 1973. The stimulus was from individual acceptors, who quickly perceived there should be an easier way of obtaining contraceptive resupply (the West Java program is 85% pill). Accordingly, in 1974 a small R & D project was designed by the BKKBN to test a variety of methods of introducing contraceptive resupply in the village, thus obviating the monthly trip to the sometimes distant clinic. It quickly became evident that the system of establishing a resupply depot in the home of an acceptor who was also an informal village leader was the most workable. The depot holder was resupplied by the fieldworker from the clinic who brought the village's monthly contraceptive supplies. The fieldworker also reviewed the depot holder's record keeping and advised on any complaints during the previous month.

Following this pilot test, this system was rapidly expanded throughout West Java and there are now about 1,600 village distribution centers (VCDC). In West Java one village (a unit of local government) may be spread over a fairly large area and broken into several "kampongs". Following the establishment of the VCDCs in West Java, family planning groups were quickly formed at the kampong level and leaders elected to go to the village VCDC to obtain contraceptive supplies. In West Java and other provinces the leader of the VCDC usually receives the equivalent of $2.50 a month, while the kampong family planning groups are volunteers. All appear to enjoy participating in the program and see it as an important community development activity. An interesting sidelight has been the venturing of some of the West Java family planning groups into other village development activities. Some groups, formed for the purpose of family planning, have branched out into sewing, cooking and nutrition courses and other cooperative type activities. Such extension encourages other women to join the group.

Central Java. Village distribution of contraceptives was initiated in Central Java on a small scale with provincial funds in 1974 and then expanded rapidly in March 1975 with central funding. The system differs somewhat from that of West Java as the village distributor is usually a member of the village headman's staff. In late 1975, the Governor of Central Java ordered that the village contraceptive distributor be made a member of the Village Social Institute under the Ministry of Interior. There is a Village Social Institute active in each one of Central Java's 8,315 villages which is responsible for overall village development activities.

In Central Java, if a woman does not appear for her monthly supply the VCDC operator will sometimes deliver the supplies to the woman's home. As in West Java, at the sub-village level family planning groups called "Pagayuban" have sprung-up around the concept of sending the leader to the VCDC to obtain the monthly supplies. These groups have shown interest in branching out from their family planning activities. One group visited in early 1976 had started a chicken cooperative.

East Java. Village contraceptive distribution in East Java was initiated by order of the Governor in September 1974, and funds were provided to expand village distribution in early 1975. The VCDC operator in East Java is usually a member of the village headman's staff; his duties are primarily contraceptive resupply and acceptor follow-up and maintenance. In some of the villages in East Java, a special "pill day" has been organized in which all the women assemble at the same time for resupply. The VCDC operator often reads the roll of all registered users of contraceptives and as each woman's name is called she comes forward and pays 35 rupiah (about 95 US cents) and receives her next month's supply of pills or condoms. She is asked if she has had any difficulties to report. Most women don't, but those who do are turned over to the nurse-midwife who visits the village on pill day to provide care or advice.

Of the 35 rupiah received from each woman, 10 are kept for the costs of record keeping and the other 25 are added to a rotating lottery fund. This ingenious feature is a combination of respectable gambling and a savings account. One person each month wins the prize until each person has won. Sometimes it amounts to over Rp 4,000, which is enough to buy material to clothe a family for a year, to lend out at 5 or 10 percent a month, or to repay debts. In this system the luckiest winner gets her investment back in the first month. The least lucky may wait ten years, but as one observer noted, "In our rosy dreams, we are never the last." The lottery acts as a magnet for new acceptors: old acceptors encourage others to join in order to enlarge the payout. Young marrieds are eager to join in order to have a chance at the prize, which would provide them with a welcome fund for starting off their new life.

Bali. Bali's system is somewhat different than the village family planning systems on Java. It revolves around the "banjar", a sub-village organization of which there are some 3,600 on Bali with an average population of some 600 per banjar. In the Balinese scheme of life, the banjar combines religious (Hindu) tradition with secular and local official functions. It is, in effect, their social security and as such is extremely cohesive and self-reinforcing. The banjar family planning system not only includes contraceptive resupply, but also a registration and mapping system in which family planning users are followed-up monthly and their status noted on a prominently displayed banjar map. As the Bali program is largely an IUD program, less emphasis has been placed on contraceptive resupply and increased emphasis on recruiting new acceptors and maintaining those already in the program. Currently 1,800 banjars are participating in the program, and in these about 60% of the eligible couples are using family planning. All banjars are expected to be covered by the end of 1976.

In summary, the guiding concepts of Java and Bali village family planning have been non-standardization; maintaining a link to the clinic in the movement to the village; focusing first on contraceptive resupply; and the concerted effort to integrate family planning services into the village in order to make family planning easier and more attractive. An unexpected spillover of this movement has been the development of sub-village family planning groups with the desire and energy to expand their activities beyond family planning into self-help developmental activities. It may be that bringing family planning users together creates an unexpected dynamic.

Evaluation of the VCDCs

Data have not yet been assembled that could demonstrate the specific effects of the VCDCs. The VCDC program has moved too quickly to allow the setting-up of control areas - none of the villages would agree to being left out. There is a positive relationship between contraceptive use by province and the number of outlets per MWRA (married women aged 15-44). In Jakarta and West Java, for example, where there are still few outlets per MWRA, contraceptive use is relatively low. In East Java and Bali with many outlets, contraceptive usage is 32%. Some provinces have been relatively successful in establishing and operating the VCDC system in under one year, due to the grassroots demand for this service plus the strong support of the government at each level of administration from the province to the sub-village.

One measure of VCDC success is the rate of utilization. In absolute terms, the number of cycles distributed has grown rapidly though erratically. From BKKBN statistics it can be ascertained that in April 1974 about 20% of the contraceptive supplies were distributed outside the clinics through an "informal" system that had been operating. Fieldworkers would hand-carry supplies for neighbors who, for one reason or another, could not come to the clinic. From this informal system the program has moved to the more formal systems described above. By March 1976, 56% of all pills were distributed through the VCDCs or their attendant family planning groups.

The numbers of new acceptors for Java and Bali increased rapidly in 1969-72, but the trend in acceptance growth appeared to be leveling off (plateauing?) from 1972 to 1974. Then in 1975, new acceptance growth increased again coincident with the inception of the VCDC across Java and Bali. There were other new developments occurring at the same time, but the VCDC was by far the most dramatic. Both the age and the numbers of living children of acceptors have continued to drop consistently from 1971-1975. The median age of new pill acceptors declined slightly until 1975 when it fell sharply, indicating younger women with fewer children than those who came to the clinics.

[Extracted from an unpublished report prepared for the U. S. Agency for International Development, June, 1976.]

China's Experience with Motivation for Family Planning

Leo A. Orleans

[China's methods of stimulating motivation to follow family planning practices are unique, and while they are not readily adaptable to other countries they are of interest in view of their importance for this country's very large population.]

The earliest family planning programs in developing countries concentrated on reaching the population through the standard channels of mass media - radio, newspapers and magazines, family planning posters and pamphlets, and a variety of mailings, primarily of visual educational materials. All these continue to play an important part in the birth control persuasion effort around the world, but over the years it has been clearly demonstrated that as important as mass media are, they can be only one of the approaches to the desired goal. This form of propaganda usually is more effective in a more literate urban population which is already in the process of changing its way of life - one that includes migrants from the rural areas who are integrating into the urban society, gradually shifting their allegiance from the family to society as a whole. Mass media are much less likely to be effective in a rural population - to convince the illiterate masses they must change the traditional point of view toward children and family, or to induce a young couple to adopt contraceptives and limit the size of their family. In the rural setting (and in the urban too, for that matter) more and more effort in "selling" family planning has been concentrated on the more intimate, interpersonal form of communication that makes more use of local personnel and attempts to tailor the message to the specific audience addressed. This approach

Mr. Orleans is a Chinese Research Specialist at the U. S. Library of Congress, Washington, D. C.

came about slowly, following lengthy experimentation with other methods of communication and still faces many difficult problems such as the recruitment of credible and trustworthy disseminators, matching the message to the local customs and proprieties, and increased costs.

But even the much more effective personal approach still runs smack into the problem of motivation. In other words, the use of contraceptives or the will to be sterilized does not necessarily follow the abstract knowledge about "how" and "why", but usually requires an additional motive that is more personal and immediate. To cope with the problem of motivating people to limit their families in rural areas of developing countries that have not yet experienced significant social and economic changes, governments and interested organizations have been experimenting with a variety of ways to compensate families or individuals who do make an effort to limit the number of children. Many of these schemes have become quite imaginative and go well beyond the payment of cash and material goods that are still widely used, especially to induce persons to accept sterilization or agree to an insertion of an IUD. More sophisticated approaches are becoming common. There is a district in Taiwan, for example, that has been experimenting with education bonds to cover tuition to parents who have no more than three children. And in South India, a savings deposit scheme has been introduced to provide old-age security for parents who agree to limit family size. Theoretically, such inducements are superior to cash payments, but understandably, peasants who are not accustomed to long-range planning will be difficult to convince. In addition to compensating those who agree to accept some method to control family size, incentives have also been provided to "change agents" or "finders" of individuals willing to be sterilized or to wear an IUD, for example. Although the use of negative incentives - increased taxation, withdrawal of certain benefits, other penalties - has been suggested, the idea is quickly abandoned because the people most affected by these measures are already too poor to pay taxes, and so miserable that additional penalties would be counter productive for the country and would hardly be noticed by the family.

Aside from the question of political and ethical acceptability, incentives can become quite costly and, if delayed benefits are involved as in the case of educational costs and old age security, they can also involve complicated and expensive administrative activities. Witness: Almost one-quarter of India's total family planning budget for the 1969-7 5-year plan is designated for incentives. Despite these high costs, however, there seems to be no other form of effective motivation available to the developing countries so that from the government's point of view the prices paid for incentives is still smaller than the cost of bearing and raising a child.

During the 1950's China also undertook the standard approach to disseminating family planning information. In the first birth control campaign the mass media was fully mobilized. Information was presented on the radio, in movies, in special exhibits and slide presentations and, of course, in the thousands of articles in newspapers and magazines and millions of pamphlets, posters, lantern slides and other visual aids. A certain amount of personal testimony and persuasion was also given by opinion leaders such as local cadres, doctors, and others in influential positions. This was not enough, however. The population was not yet adequately motivated to accept this media-intense but personally remote approach. Neither were the masses ready to be influenced by intangible incentives to delay marriage and space births in order to contribute to the "Socialist construction of the fatherland."

Today, family planning communication and motivation in China are so different from those found anywhere else in the world that a direct comparison is impossible to make. The number of articles in the Chinese printed media discussing some aspect of family planning is rather limited, yet the national objective to reduce the country's birth rate is communicated in a campaign that is as intensive and persuasive as any that the Chinese have ever launched. Although posters, pamphlets and the ever-present public loudspeakers are still widely used in family planning education, primary reliance is centered on the political and social structure of both the urban and rural communities. Even the role of the public health personnel - the role so vital in the family planning program - is essentially related to technical aspects. It is much more the responsibility of what the Chinese refer to as grass-root organizations, which often include friends, neighbors, and working associates, to educate the young people in the need for the postponement of marriage and, within the marriage relationship, to persuade them to seek the birth control assistance that is provided by the public health personnel - physicians, nurses, barefoot doctors, and other medically trained individuals.

As for monetary or other financial incentives, they are obviously out of the question in China; but the exhortations to serve the people and the fatherland that had minimal influence for family planning in the 1950's have become much more effective with the new, post-1949 generation. Sincerity in China is almost impossible to judge. The praise of the leadership and of fellow comrades (albeit often organized) may not be the greatest reward, but it is very important in the new society, where esteem is accrued through public recognition and disapprobation through public criticism. China is now reaching a point where at least part of this approval or disapproval depends on the size of a couple's family and, as will be seen, constitutes adequate motivation for the planning of births.

Motivation Chinese Style

First there is, of course, the Communist Party, which plays a leading role in promulgating all policies announced by the regime and whose members are in key positions of all organizations involved in the birth control program. Party members coordinate and lead the activities of labor unions, women's federations, the Young Communist League and other mass political and social organizations which play such an important role in all national campaigns and are now deeply involved in educating and persuading people to plan births. It is usually these organizations that, in conjunction with the public health organizations and personnel convene provincial and county level birth control work conferences. The national involvement in family planning is well illustrated by the following statement from one such conference:

> Under the party's centralized leadership, the trade unions at all levels and the youth, women's, poor and lower-middle peasant and militia organizations as well as the relevant departments such as culture and education, public health, industry, commerce, civil affairs and public security must work together closely to jointly make a success of birth control work.

After a conference participants are informed of the latest policies and plans and have an opportunity to discuss the various measures and approaches and to "exchange experiences," returning to their communities to "implement the spirit of the conference".

Since family planning is a national policy it is also the responsibility of each local government with its authority vested in a Revolutionary Committee. Most of the Revolutionary Committees have established a Committee on Planned Childbirth consisting of at least one member of the parent committee and, for the most part, women from rural production teams or urban neighborhoods who are involved in civic activities, education, propaganda, or some function relating to the status of women in the community. They also include either a full-time or part-time health worker who is capable of providing more specific information with regard to birth control means and methods and who constitutes an important link with the public health system. At the lowest residential levels there are Subcommittees on Planned Childbirth which function with close collaboration with or as a part of street committees which are extremely important in the social, political and economic life of each neighborhood.

Now let us consider more specifically some of the forces within a given community that are more likely to influence a young couple's decision with regard to size of family and spacing of children. One or both members of the young married couple are likely to belong to a bra of at least one of the already mentioned mass organizations such as the Youth League, Women's Federation, Trade Union - each of which plays a very prominent role in their lives. Membership depends to a great extent on compliance and conformity and on activism and participation.

To belong is to support and implement national policies and, as a national policy, the planning of births is of concern to the total membership. Furthermore, virtually every young person, man or woman, is presently in the labor force. The involvement of the management of the institution or enterprise and of the other workers and employees or peasants in the personal lives of each individual extends considerably beyond work-related subjects. "Experience exchange" meetings and discussions go beyond production quotas and problems, and study topics related to family planning are common, particularly "on the eve of big holidays" and especially in institutions where women constitute a large proportion of the labor force. It is not unusual for the women workers in a factory, for example, to announce their joint decision as to the number of births they will collectively have during the following year, or to see a chart on the wall of a hospital or an office again indicating the planned number of births for some specified period of time.

At the residential level, the peer pressures are even more pervasive and certainly more personal. The street health center and the village health room are the focal points of birth planning. It is here, for example, that our young married woman will probably have her name, along with the names of other women in her neighborhood, on a wall chart that depicts the menstrual cycle of each woman, the type of contraceptive the couple uses, the presence of absence of the husband and other pertinent information. It is also from these residential health centers that local women, who may be responsible for no more than 20 to 40 households, are designated to oversee the family planning program, stay in touch with mothers and potential mothers, and personally guide and assist them in the practice of their birth control functions. These basic-level cadres or activists constitute the backbone of the birth planning program. Residential meetings, so common in China and dealing with everything from garbage disposal to domestic problems, are also convened to study and discuss the specific problems relating to family planning, from advantages of marrying late and types of contraceptives to abortion and sterilization. The meetings are usually led by women cadres from the health services or from one of the mass organizations. They know the Party line, how to interpret it and how to communicate it to the group. With the constant reminder both at work and at home about the desirability of having few children, it would be extremely difficult for our young couple - and especially for the female - to slip up.

This special character of the pressures that motivate the Chinese family in the planning of births is aptly analyzed by Professor Liu:

> Since peer group pressure is extensive and intensive, reactions to pressures tend to be circular, involving not one or two individuals as in the case of intergenerational pressures, but a larger number of friendship circles, all of which are proximate, and their collective force far exceeds singular pressure.

The infrequent suggestion by overly-enthusiastic cadres that a more direct approach be tried, one that would "lay down a few hard and fast regulations, so that time could be saved and quick results produced," are quickly rejected with the admonition that success can only come by relying on the "consciousness of the broad masses."

Although the public (or group) discussion of sex-related subjects is in no way typical of the Chinese culture and could only be instituted gradually and with difficulty, the process was undoubtedly helped by the fact that privacy, so valued in Western societies, is virtually non-existent in China. Even more so now than in the past, the community or neighborhood will, as a matter of course, arbitrate domestic quarrels, know every detail of a person's or family's financial status, help a family with a mentally disturbed or retarded member, and so forth. It is only within this social and cultural environment that the effectiveness of peer pressures in the planning of births can be adequately understood.

Despite claims of considerable progress in breaking down traditional attitudes, the Chinese do admit that "family planning work is by no means a soft task" and occasionally report the problems encountered by persons responsible for propagandizing planned parenthood. Here is one interesting case history from Shanghai:

> A woman worker in a toy factory already had two girls. Influenced by the idea that "boys are better than girls," she herself, her husband, and her mother-in-law all hoped for a boy. The neighborhood committee cadres and propagandists went to their home to do ideological work, explained the advantages of planned parenthood, and convinced first the woman and then her husband. Finally, the cadres and propagandists and the couple worked on the mother-in-law. Birth control measures were adopted promptly.

This case not only shows the perseverance of the neighborhood planned parenthood cadres and the personal approach they are able to take, but also reflects the persistence of traditional attitudes even in the cities, and the continuing influence of the older generation in the lives of young Chinese people.

This involvement and intimacy in the current family planning program is also well illustrated by a relatively new approach which parallels China's contention that "along with the practice of planned economy there should also be the planning of births." Apparently in some of the more advanced communes and in some urban neighborhoods, married women of reproductive age hold meetings at which detailed plans are made as to who in the group will have children during the forthcoming years. The discussion takes into consideration such factors as the size of present family and the length of marriage; the final plan, often represented on wall charts, shows that Mrs. X will have her next child in 1975, Mrs. Y and Mrs. Z in 1976 and so on. These discussions are guided by members of birth control committees or public health workers who follow the edict that:

> In deciding on population plans, it is necessary to have the masses participate fully, to send the plans to each household and work out plans for each person, so that the leadership will have definite plans and the masses will clearly understand them.

Another example of the workings of this system was reported by Han Suyin. She tells of how each courtyard in Peking held meetings to debate which of the families would have a baby the following year. "The families have to agree, between them, whose turn it will be to have or not to have a baby." Apparently one woman got pregnant out of turn, which meant that her neighbor, who was scheduled to have a baby, would not be able to do so. To show her public spirit, the pregnant woman had an abortion.

The story tells us of the system and of the spirit that exists in China. Their approach to family planning does not resemble any methods to be found in any other country. Everyone is expected to be involved in the new ideology and habit of "practicing birth control for the revolution." And when everyone is involved there is a different feeling among the participants; perhaps a feeling of togetherness rather than one of isolation when a family as a single unit has to bear the attention and the pressure of family planning personnel. The practice of birth control in China may not yet be "a compelling demand and spontaneous action of the masses," but there does seem to be a reasonable basis for the statement made at a Kweichow Province conference on birth control work that "the new custom of regarding birth control as honorable is gradually forming in the towns and countryside throughout the province" - and probably throughout most of the country.

[Extracted from China's Experience in Population Control: the Elusive Model, pp. 26-32, prepared for the Committee on Foreign Affairs, U.S. House of Representatives. U.S. Government Printing Office, Washington D.C., 1974]

Population Policy and Research

Ronald G. Ridker

[This article reviews the evidence on possibilities for restraining population growth through a variety of government policies (other than family planning programs). Areas in which policy effects might be found include: education, especially female; employment generation, especially for women; income distribution; incentive programs; social security; health; mass media and urban planning.]

Within the broad spectrum of proposals aired at the Bucharest World Population Conference in 1974, the two policies most commonly advocated for reducing population growth in poor countries were: rapid economic growth, and more effective family-planning programs. The former, it is believed, creates the desire for smaller families, and the latter provide the means. There is evidence to support both positions. No country has ever achieved a high standard of living without experiencing a significant decline in its birth rate. Nor has any sizable country in modern times experienced low birth rates over sustained periods in the absence of significant economic growth. Moreover, some hopeful signs in one or two of the developing countries indicate that birth rates may fall in the next few decades before development reaches high levels.

There is also growing evidence from a variety of countries which suggests that easier access to the information, services, and supplies provided by modern family-planning programs is effective in reducing the gap between desired and actual family size. The extent of the effect in relation to the effort involved is difficult to judge because of substitutions between methods, simultaneously occurring social and economic changes that also influence family size, and difficulties in measuring levels and

Dr. Ridker is an economist with Resources for the Future, Inc., Washington, D. C.

and quality of effort. But there is no reason to doubt that such programs are capable of reaching and influencing those persons who are already motivated or easily encouraged to have small families.

For countries with good prospects for rapid socioeconomic development and reasonably good administrative infrastructures, sustained efforts in both these directions may indeed prove to be sufficient, though the time lags involved could be substantial. The most difficult problem arises in those countries that cannot achieve adequate rates of development in the near future, just because of rapid population growth. In such cases, the number of persons desiring small families may not grow fast enough to give even the best-run family-planning program enough to work on. If population growth is to be curbed reasonably soon, such countries must search for a third approach. This article surveys current progress in that search. Each topic presented here focuses on one hypothesized socio-economic determinant of fertility believed to be amenable to policy manipulation. [Names mentioned in the text below refer to authors of other chapters in the book from which this article was extracted.]

Income and Its Distribution

A wide array of mixed results are found in studies that attempt to relate income to fertility. Some find a positive, others a negative, and still others a shifting relationship as family income rises from low levels; in a few studies no relationship at all is found. Part of the reason is weakness in the available data. Income, for example, should ideally mean the full family income a couple expects to receive over their lifetimes, not the money income received in a particular year and certainly not some per capita average. Most important is the failure to separate statistically the demographic effects of income from those of other variables: practically all socioeconomic variables that might be important in explaining fertility are also correlated with income.

Julian L. Simon divides these income studies into two groups: those that are more appropriate for measuring short-run, direct effects of income, and those that come closer to measuring the long-run total effects. Since the immediate effect of an increase in income is to make it easier to finance marriage and support children, one would expect the short-run, direct effect to be positive: more income encourages larger families. This is just what Simon finds. In constrast, the long-run, total effect tends to be negative, at least above the lowest income levels.

Unfortunately, these findings are of little help in making policy recommendations. The short-run effect is positive rather than negative; to take full advantage of the long-run effect requires sustained economic development (which presumably is being pushed as fast as it can be in any case). More to the point, these findings are too general and unspecific to be useful for policy. The effect of a change in income is likely to vary depending on whose income is being changed (which socioeconomic groups and which family members), how it is changed (through transfers, changes in the labor market such as increased wages or opportunities for more work, or changes in the ownership of wealth, for example), and whether the change is considered transitory or permanent. It is at this level of detail that we are likely to find useful policy suggestions. For example, while the short-run effects on fertility of an increase in adult male earning and in opportunities for child labor are likely to be positive, both the short run and the long-run effects of an increase in female wages, or opportunities for work outside the home, could well be strongly negative.

Recent thinking about economic development has shifted somewhat away from an emphasis on general economic development toward a concern for the poorest segments of the population. Frustrated attempts to raise national growth rates to acceptable levels in some countries, growing evidence that the poor often do not participate in whatever national growth there is, and recent concerns that the rural poor may have to be enlisted in the development process if adequate supplies of food and agricultural raw materials are to be forthcoming for other segments of the population have all come together to explain this new emphasis. Parallel with this shift in focus of development programs have come suggestions that redistribution of income might also encourage a more rapid rate of decline in the birth rate. Typically, the poorer 60 percent of households receive 30 percent of the national income but have fertility rates some 50 percent higher than the richer 40 percent of households. If socioeconomic development were concentrate here, perhaps the national birth rate could be reduced by a larger amount per dollar of investment than it could by an across-the-board approach.

The little evidence that is available is certainly encouraging. But several questions can be raised: First, why should a redistribution of income in favor of the poor be effective in lowering their birth rates? If the argument is based on the assumption of emulation of upper-income-class norms, it is not at all certain which way completed family size would be affected. Is it the desire of lower-income groups to emulate the consumption patterns , or the completed family size, of the rich? If the former, the poor should now be having fewer children than do the rich, and an increase in their income would raise their fertility. If the latter, fertility would fall with an increase in income as the poor acquired the knowledge and means to purchase modern contraceptives. But surely a cheaper way to close this gap in knowledge and means would be through a focused program of family planning. And if the argument is based on the long-run, total effects of the change in absolute level of income, we must ask whether the total effects are likely to occur as a consequence of incom redistribution alone - that is, without concomitant changes in the provision of social overhead capital and other structural changes, including urbanization and occupational changes, which are normally associated with modernization and development. Unfortunately the evidence is based on data that do not permit us to answer such questions. It is virtually impossible to hold cultural and institutional variable constant in cross-country comparisons.

The overall impression with which one is left is that unconditional transfers of income to the poor, while they could well be effective in lowering fertility in the long run, operate through a wide variety of other variables associated with modernization and development. If one is to speed up the process, either these other variables must be identified and the most critical ones changed as a package along with income (or the capacity to produce income), or the transfer must be made conditional upon an appropriate fertility response.

Economic Value of Children

No one would claim that children are desired solely or even primarily because of their value as productive economic assets, but it would be a rare case in which this consideration was entirely absent. And so long as it is present to some degree, the economic benefits and costs of children are worth investigating, for they are far more capable of being influenced by policy than are most of the noneconomic values associated with children. The two principal components of the economic value of children are: the net contribution that children make to the family's income through their work (their production minus their consumption), and the contribution they make later in life to the support of aging parents. Unfortunately, the available evidence is not only spotty and scarce, it is also ill suited for policy analysis.

Attitude surveys, anecdotal evidence, and even some a priori reasoning suggest that raising children provides some net economic benefits to parents, at least in peasant societies. But after carefully sifting through the evidence Eva Mueller finds that children are usually a heavy economic burden. Up to some age between fifteen and nineteen they produce substantially less than they consume; indeed, aggregate production does not equal aggregate consumption, even by a male, until some time in his twenties, when he begins to have his own children to support. This finding is particularly significant, first because Mueller makes an extreme effort to find positive asset values for children at birth (for example, by choice of assumptions on hours of work, wages and consumption, and by not discounting), and second, because if such values are negative in peasant societies, they are surely negative for the rest of society, in particular for urban areas where the costs of child rearing tend to be higher and the possiblities for contributing to family income at early ages tend to be lower.

This conclusion is supported by evidence indicating that in developing countries children under the age of fifteen do little economic work (that is, work contributing to marketable output), and that their productivity when working, even during peak seasons,tends to be low (productivity being judged according to the wages that would be received for the same work in the marketplace). It can be argued that this definition of productivity excludes housework by children. But since children also create the need for additional housework, a correction for this factor is unlikely to change the overall result significantly. It can be pointed out that the use of wages, even during peak seasons, represents an underestimation of the importance of having children available to fill in when needed. But it is difficult to believe that day labor hired during peak seasons would be more expensive than children who have to be supported throughout the year. School attendance by children under fifteen partly explains the low labor-participation rates by children found in these studies; but low attendance rates and the possiblity of fitting farm work in around school work suggest that this is not the principal reason. The most likely and obvious explanation for these findings of low child labor-participation rates is simply that labor in general is in excess supply in the countrysides of the developing countries with which we are dealing. If this analysis is correct, we must reckon with the likelihood that efforts to increase agricultural output will result in increased employment opportunities for children along with those for rural labor in general. Thus, the scope for policy intervention to decrease the demand for child labor is quite limited. The relevant bits and pieces of econometric, historical, and sociological materials combine to suggest that while a decline in demand for child labor will lead to a decline in fertility, the effect is likely to be small and the time lags involved quite long. Given that child labor-participation rates are already low, plus the likelihood that agricultural investments may increase the demand for child labor, there is little room for manipulating this variable by itself.

The evidence with respect to old-age support is mostly qualitative and indirect. It emerged strongly in attitude surveys in countries where strong family ties are traditional, but little is known about the actual extent of the transfers. Mueller finds that older rural males continue working on family farms until very close to the age of death and thus may not be receiving substantial transfers from their children. But little is known about the kind and productivity of the work involved or whether this finding is applicable to those without the opportunity to work on family farms. Moreover, labor-participation rates for older women are considerably lower than for elderly men, suggesting that some transfers must be forthcoming at least for them.

Perhaps more to the point, one can ask whether investments in children are the best way to provide for one's needs in old age. Robert G. Repetto makes a plausible case that they are not: there is no certainty of a child's surviving and being willing and able to provide support; and there are periods during the life cycle when surpluses are easier to accumulate along with mechanisms to transfer these surpluses to later stages in life. Land could be purchased in small increments; durables like gold ornaments etc., can be accumulated; and even those in debt could increase their uncommitted income significantly by reducing their indebtedness.

On the other hand, there are sustantial risks involved in attempting to save and transfer surpluses from one period to another over one's lifetime. Farm investments are illiquid; money and jewelry can depreciate or be stolen; commercial institutions can go bankrupt. Indeed because of inflation and the risks of theft, fire, floods, confiscation, and other calamities, the perceived long-run rate of return on many possible investments may well be negative. At least the peasant may feel that the situation is too dangerous to rely on any one approach, so that he may prefer to save and to have children in case one of these approaches fails. The cost of bringing children into the world is not very high, and the costs of supporting them are spread over at least ten to fifteen years. Accordingly, even if the economic return for having a child is negative, it may be less negative than alternative investment. In any case, all such arguments may be overshadowed by the fact of long widowhood in societies where women have little economic power and even less knowledge of economics. To them, children, and especially sons, may appear to be all that will save them from destitution after their husbands are dead, no matter what the economic facts may be.

Efforts to improve access to savings institutions and to reduce the risks and improve the returns from such invesments would be helpful in reducing the pension value of children, as well as being useful for general economic development. So, too, would the promotion of life insurance, private pension plans, and other contractual savings arrangements, since they tend to bring about a net increase in the average rate of savings. Government-sponsored social security programs would help; but they can be quite costly.

Education

The linkage between education and fertility poses a paradox for both researcher and policy maker. On the one hand, no other socioeconomic variable seems to have a stronger negative association with fertility. Parents with more education have smaller families, and parents whose children have more education also have smaller families. These relationships hold in both cross-section and time-series studies at both the national and the family levels, and whether or not other variables such as income and place of residence are controlled. While in some studies it has been found that the relationship is positive for families with only a few years of primary education - suggesting the possiblity that it is necessary to achieve a certain threshold before the negative impact takes hold - these are exceptions to the general impression to be derived from reviews of the literature. On the other hand, research has not provided adequate explanations for these correlations, with the consequence that most policy recommendations in this area remain on uncertain ground.

The Effect on Parents' Desire for Additional Children. It is difficult to foresee what kinds of effects on parents' tastes and preferences might arise solely from providing more education to their children. But there are several income and price effects that could be important. First, the additional years of schooling place two burdens on the family budget: they reduce the income which children would otherwise contribute to the family and, depending on the way in which costs of education are met from private payments, they increase the direct cost of rearing children. Second, the additional schooling increases the parents' expectations of receiving larger income transfers from a given child later in life, reducing the number of children needed to help with old-age security. And third, if the effective price of schooling were reduced, it could become more profitable for parents to invest more in fewer children, substituting "quality" for "quantity."

Doubts can be raised about the importance of these effects, especially in peasant societies. The direct costs of sending children to public schools, especially in primary years, is typically small, and is offset by the baby-sitting function served by schools (the value of this service is smaller where older children are available to care for younger). Moreover, economic transfers from better-educated children later in life are far from certain, not only because of high death rates but also because educated children are more likely to leave the extended family network of ties and obligations. Unless death rates fall and the net returns to education are increased significantly, parents may not be willing to give up security in numbers for improvements in quality. In any event, the time lags involved in trying to persuade them to do so are likely to be substantial. Nevertheless, even small changes add up over time.

The Effect on Children's Subsequent Fertility. Here we can be somewhat more confident of finding a significant negative effect on fertility. First, there are a number of attitudinal changes associated with the acquisition of education that are likely to reduce the desire for a large number of offspring, independent of any income/cost effects. Education, according to Donald B. Holsinger and John D. Kasarda, increases exposure to appeals in the communications media aimed at encouraging family planning; increases aspirations for upward mobility and accumulation of wealth, making one less interested in - or at least more desirous of postponing - the rearing of a large family; imparts a sense of ability to control one's own life and environment, thereby making family planning and the use of contraceptives appear less foreign; and encourage one to think about nontraditional ways of living one's life.

Working in the opposite direction is the income effect of education, which makes it possible for the better educated to afford large families. But as Dennis N. De Tray points out in reviewing studies attempting to separate and measure the income and cost effects, the latter are all negative and appear to be sufficiently important quantitatively to offset the positive effects of income on fertility. These cost effects are thought to be of the following types: education of women enhances opportunities for employment that are competitive with having and rearing children, thereby increasing the opportunity cost of children. Education of both parents tends to raise the educational norm that they expect to provide to their children, thereby raising the cost of child rearing. It also seems to increase the capacity for effective use of contraceptive devices, and for communication between husband and wife about such sensitive matters as family size and the use of contraceptives (thereby lowering the effective "cost" of achieving a given family-size norm). Since school and marriage are generally considered incompatible, the provision of more education tends to delay the age of marriage. Education helps parents reduce child mortality, thereby lowering the number of births required to achieve a given family-size norm and encouraging investments in quality rather than quantity. Finally, as a consequence of increased education, parents are more likely to be able to take care of themselves in their old age, thereby needing children for this purpose to a lesser extent. Information on the magnitude of these effects, however, is scarce and generally of poor quality.

School Attendance. If education is of value, then the principal need is for more facilities and teachers. Given the budgetary constraints in low-income countries with rapidly growing populations, any additional resources made available to the education sector must be allocated with care. Highest priority should be given to primary education in poor rural areas where birth rates are highest. An immediate antinatalist effect might be introduced by allocating facilities within this high-priority area on a conditional or incentive basis - that is, to those rural villages meeting certain family-planning targets.

But lack of facilities is not the only problem: available facilities are frequently underutilized because of poor attendance. There are four possible ways to ameliorate this situation. The first, compulsory attendance laws, can be set aside as unworkable. The second, subsidies or monetary incentives for attendance, does not seem promising in view of budgetary stringencies. However, the subsidy could be given only to those families with fewer than a certain number of children, as is being tried experimentally in Taiwan. A third possibility is to improve the relevance of education to the individual's daily life. A peasant has little incentive to keep his child in school if he believes that the child is not receiving much of value. One way to enhance the value of education is to change the environment in ways that increase the need for education. An education is of little value to a girl who will never take a job; even literacy is of little value unless there is some need to read. Suppose, for example, that jobs in the education and health sectors requiring a certain number of years of schooling were made available to girls. Such a change could make the difference between sending and not sending a daughter to school. However, there is little or no evidence available so far to measure the effectiveness of these presumptions and suggestions.

Mortality, Morbidity, and Nutrition

It is frequently alleged that a fall in child death rates and better health and nutrition are necessary preconditions for a fall in fertility. Cross-country and historical evidence tend to support this proposition. But what role do these health-related factors play, independent of positively correlated changes in income, education, and social structure?

Improvements in health, while not necessarily increasing the number of births, do increase the capacity to have more children. William P. Butz and Jean-Pierre Habicht find good evidence that raising the nutrition level of females results in earlier menarche, later menopause, and shorter periods of postpartum amenorrhea in nursing mothers. The linkage between male fertility and morbidity probably works in the same direction, although Butz did not find any evidence to this effect. Reductions in adult mortality, because they decrease the number of widows and widowers of reproductive ages, also increase the potential for more births. Only reductions in deaths among nursing infants point in the opposite direction, since the period of lactation and postpartum amenorrhea are therby made longer; but the contraceptive effect of this change is far from sufficient to account for the observed declines in birth rates as infant death rates have fallen. If the correlation between morbidity, mortality, and fertility is to be explained, one must look for behavioral rather than physiological changes.

First improvement in general health and a decline in child mortality can be expected to increase desired family size, since the expected cost of rearing a survivor is thereby reduced and the benefits increased. Second, a decline in child mortality means that fewer births are required to achieve a given number of survivors. T Paul Schultz shows that, given plausible assumptions about response elasticities, the net effect of these first two factors is to reduce births. But this decline in births is unlikely to be sufficient to offset the increase in population growth resulting from the decline in mortality unless additional behavioral factors are brought into play. One such factor is the response of parents to uncertainty. A plausible response is overcompensation: parents may well prefer to have too many rather than too few surviving children. If this is the case, a reduction in child mortality, which is generally accompanied by a reduction in uncertainty as well, would reduce births by somewhat more than is implied by the first two factors alone. Fourth and perhaps most important, improvements in the rates of mortality and morbidity and in nutrition at all ages increase the relative returns on investments in human capital. These effects should encourage parents to invest more in both their own and their children's education and health, and make them willing to have fewer children in order to finance such expenditures. They could also make it somewhat more attractive to postpone marriage to the extent that marriage and early child rearing are incompatible with investments in education.

While all these effects are plausible and more or less consistent with the evidence, there is very little information on their quantitative magnitude and none that adequately separates the various effects and lines of causation, including the biological, from each other. It is typical in less developed countries to find that the decline in child death rates precedes the decline in birth rates by at least a decade, and that the decline in the latter compensates for less than the total decline in the former, leaving family size and the growth rate of population somewhat larger. But the variance around this average is sizable: Schultz, for example, finds that in about half the studies he reviewed response rates in excess of unity are implied, and an explanation for these differences is lacking. One cannot go further than this with the data, virtually all of which are cross-sectional, and the methods available at present.

It seems reasonably certain that improvements in medical and health care will eventually encourage some decline in fertility. Beyond this statement, however, lie many unanswered questions, particularly concerning the extent and speed of the decline, the resulting effect on the population growth rate, and the overall cost-effectiveness of alternative methods of improving medical and health care. One suggestion may be offered as an example of the kind of focus in health programs which might have pertinence to their fertility effects. The major causes of child mortality are gastroenteritis and diarrheal diseases. Public health investments in providing potable water and sanitary waste-disposal systems in rural areas, plus education campaigns directed specifically at this problem, should have a high rate of return independent of general advances in economic welfare.

Female Roles and Labor-force Participation

Some studies have indicated that high fertility rates in many developing countries are related importantly to the social and economic roles assigned to women, and that the best way to change this situation is through changes in female employment. Women in a large number of developing countries, and especially in the rural sectors of these countries, are described by Ruth B. Dixon as powerless, economically and socially dependent, and isolated from the mainstream of life outside the family circle. In Moslem societies, on which she concentrates, this situation is related to the practice of female seclusion. Among other things, it leads to limitations on economic activities outside the home. This makes daughters a greater economic burden on their parents, resulting in their receiving less education and leaving them with fewer ways to attain status and security besides early marriage and the production of children. While arising for different reasons and in different guises in non-Moslem societies, the more general features of this situation are not unfamiliar in large parts of Latin America and Africa.

The possibility that provision of better wages and jobs for women outside the home could change this situation and lead to a decline in fertility arises for two reasons: the roles of worker and mother tend to be incompatible; and a job and an independent source of earnings may give a woman a greater voice in family decision making.

James L. McCabe and Mark R. Rosenzweig, however, note several reasons why a positive relationship between female earnings and fertility may occur in developing countries. First is the income effect, allowing families to afford more children, which could be much stronger at low levels of income. Poverty forces many women into the labor market when it means a reduction in the care their children get; for these women, an increase in their wage rates could well permit them to work less, increasing the amount of time they would have to bear and rear children. Second, large families make it easier to find substitutes for the mother's time in child rearing. Finally, the jobs for women in developing countries often permit caring for children while working, since they are more often performed at home than jobs in industrial countries. Role incompatibility, therefore, cannot automatically be assumed in conditions prevailing in developing countries. To ensure a negative effect on fertility, the additional jobs provided for women must be deliberately chosen or designed to be for the most part incompatible with child rearing.

The second factor presumed to lead to a decline in fertility, the greater voice in family decision making resulting from a job, is stressed by Dixon. There can be little doubt that girls with an independent source of income are in a better position to resist pressures to marry than are those without jobs. Moreover, evidence suggests that there is a positive correlation between the extent of the wife's involvement in family decision making and use of contraceptives. But once again, whether the provision of jobs per se under conditions prevailing in poor rural areas would be sufficient to encourage a greater role in decision making, and whether that in turn - independent of other changes - would lead to a decline in fertility, is open to question. It is more likely that a number of changes together - the provision of certain kinds of jobs and conditions of employment and pay, possibly combined with a self-help organization to provide education, legal and psychological support - would be required for a significant, sustained effect to be observed.

Dixon proposes the establishment of rural industrial cooperatives employing only women, or special workshops or industries for women. Several objections can be made to this approach. First, all proposals involving the development of new institutions and special projects are difficult to establish, replicate, and operate as self-supporting enterprises on a large scale. Second, investments in such special projects are often expensive on a per-person basis. Third, such efforts may fail if the male unemployment rate is too high, because men will either preempt the jobs or demand that the investments be made in directions more directly useful to them.

These problems with the special project approach have led some to argue that it is more effective to concentrate efforts on reducing the general unemployment rate and allowing the demand for female labor to increase as a natural consequence. Such a trickle-down approach seems to account in part for the increase in female employment in Pakistan, where, according to one commentator, women began to be employed in traditionally male jobs when better-paying jobs for men opened up elsewhere. But the immediate impact of such policies could well be pronatalist since they imply an increase in male earnings before female employment increases. Indeed, it could even result in some reduction in the supply of female labor as women, no longer forced by poverty into the labor market, withdrew to devote more time to child rearing. In some cultures, across-the-board efforts to increase the demand for female labor do not provide the package of changes that may be necessary to obtain a commensurate increase in the supply of female labor.

Fortunately, however, these two approaches are not mutually exclusive. While everything should be done to lower the general unemployment rate, there is no need to wait until it is reduced to acceptable levels to begin experimenting with different institutional forms and interventions in the female labor market. Such experimentation can proceed on a sufficiently small scale that it does not threaten male employment. It is only when some success has been achieved and attempts are made to expand the scale of operations that a conflict between these two approaches may arise.

Urban Residence

From sample surveys that include information on respondents' residential locations within two metropolitan areas, Ankara and Mexico City, David Goldberg finds that a significant proportion of fertility-related behavior is explained by residential location, over and above the effects of respondents' income, education, and place of birth. It is not possible to determine from his data whether this association is the result of a self-selection process - persons with similar attitudes tending to live in the same area - or whether people tend to take on the characteristics of those around them. Most likely, Goldberg suggests, both effects are present, but to the extent that the second explanation is correct a possibility for influencing fertility patterns presents itself. If planners were to locate urban infrastructure and renewal programs in such a way as to encourage small rather than large migrant clusters, and to encourage less segregation between older and newer migrants, perhaps the new migrants would become urbanized - and in the process give up their high fertility patterns - more rapidly.

Influence of the Media

It seems plausible that exposure to the mass media could influence preferences and tastes in ways that might have some effect on fertility behavior. Such exposure may inculcate new attitudes by increasing the desire for advertised products, the purchase of which would compete with the rearing of children, or by inducing identification with reference groups having fewer children or a later age of marriage. Deborah S. Freedman reviews the literature and evidence pertaining to possibilities involving the use of mass media and modern consumer goods. There are serious methodological problems in trying to judge the indirect effects of mass media, and data are very scarce. From what little there are - in particular a survey of Taiwanese husbands - Freedman finds evidence indicating that even after eliminating the effects of income, education, and ownership of modern objects an increased exposure to mass media is associated with increased use of contraceptives, higher consumption aspirations, lessened fears of child mortality, increased awareness of the costs of children, etc. The effects are small, but not much smaller than the effects of income and education (in that sample). Thus, there is a possibility that the promotion of mass media, and especially television, might have some impact on fertility. It could be objected that such a policy would encourage undesirable luxury consumption at the expense of investment. But the mass media can carry any desired message; it is not necessary that they encourage profligate styles of living. Indeed, Freedman's Taiwan data suggest that aspirations for and ownership of "modern consumer goods" are positively correlated with savings.

Some Broader Policy Implications

Several policy issues cut across all aspects of population problems. The first issue is that of incentives - that is, changes that are conditional upon a favorable change in fertility-related behavior. Incentives could be considered in conjunction with education, public health, housing, or the provision of employment opportunities for women. The second issue is the need for a group of closely related and mutually reinforcing changes. Finally, we must consider the question of priorities: given all the possibilities we have surveyed, can we say anything about which is likely to have the highest benefit-cost ratio, defining benefits and costs to include more than just the economic magnitudes involved?

Incentives. A wide variety of incentives has been suggested and a number are being tried. They can be positive (payments for acceptance of a vasectomy, for example, as in India) or negative (increased hospital and maternity fees and lower priority for public housing for parents with larger families, for example, as in Singapore). The incentive can be provided to the couple themselves, to "motivators," or to the community at large (funds for public works projects dependent on achievement by a village of low fertility targets, for example). They can be provided for changes in behavior ranging from the use of a particular method of family planning, changes in the age of marriage, increased spacing, or smaller completed family size. They can involve transfers of cash, goods, or services (the Taiwan education bond and the Pakistan proposal to offer life insurance for the oldest son, for example). Such transfers can be immediate or deferred (as in the case of the tea-estate experiment in India, in which payment at the time of retirement varies inversely with the number of children). While evidence on the effects of such schemes is sparse at present, it is likely to improve substantially in the next few years as the new schemes under way mature to the point at which evaluation becomes feasible.

Whatever their nature, there are several arguments in favor of incentives. First, they are known to work in other fields: price incentives can induce farmers to shift to new varieties, and differential tax rates can encourage investments in some fields and discourage investments in others. Second, the conditional nature of the offer reduces the social cost and risk involved in policy changes that would otherwise be difficult to reverse if the expected fertility effect is not forthcoming. For example, if a pension varied inversely with the number of children a couple had, the pronatalist effect of the higher lifetime income would be counteracted, and the schemes could be set up in such a way that no pensions would be provided unless fertility actually fell. Incentives can also help to overcome the time lags inherent in fertility-related forms of social change. For example, the principal effect of additional schooling on rural youths is felt only after they become adults; but if this schooling were offered on the condition that their parents limited family size, some of the effect would be shifted to the present child-bearing generation.

Finally, and most important, the use of incentives obviates the need for knowing in detail the nature and strength of the principal determinants of fertility. Incentives should work so long as something considered to be of value by the recipient is provided, whether or not it fully compensates him for the loss he incurs from having fewer children. It is the perceived, not the real, value of children that counts in gaining such acceptability. Some argue that people want to limit fertility but do not have effective means. Others assert that individuals have reason to limit fertility but are not sufficiently motivated because of lack of knowledge and the persistance of old attitudes and values. Still others argue that given the environment within which parents in less developed countries live they do not have good reason to lower their fertility, and cannot be motivated to do so in the absence of substantial changes. Incentives can be effective no matter which of these explanations is correct. If the first is correct, the incentive will induce people to find effective methods or demand that they be given them. If the second proves to be correct, the incentive will help speed up the adjustment process. If the third explanation is correct, the incentive serves as a substitute for the social change that has not yet occurred. At a minimum it will change behavior without affecting attitudes; but given normal dynamics of attitude formation, changes in attitude will follow the changed behavior in order to justify and rationalize the latter, thereby reinforcing the behavioral change.

There are, of course, a number of arguments on the other side. The incentive may have to be quite large, causing budgetary and possibly also political problems. Some types of incentives may be considered distasteful. Implementation of incentive programs sometimes poses difficult administrative problems among which are possibilities for the misuse of funds. And a number of persons might receive payments who would have behaved as they did in any case.

Whatever stand one may take with respect to incentives, they do appear to be an excellent instrument for experimentation. Indeed, the doubts and questions about incentives can probably not be answered otherwise. How else, for example, can one determine how large the incentive must be, or whether the administrative problems can be solved, and whether favorable or unfavorable changes in attitudes are likely to occur as a result of their use?

A Package Approach. A group of closely related and mutually reinforcing changes are likely to be much more effective than a piecemeal approach. An incentive for girls to postpone marriage will be far more effective if combined with increased opportunities for them to use their time constructively. The provision of increased educational opportunities may not be taken advantage of unless it is clear that the education is useful and needed and that it opens up additional job opportunities. Mass media may stimulate the desire for a higher standard of living, but the result will be frustration unless opportunities are provided for improving the standard of living.

To induce parents to value "quality" over "quantity" will require opportunities to increase lifetime income, better training to take advantage of these opportunities, reduced mortality to increase the expected returns from long-term investments, and, quite possibly, some kind of community or peer-group support to encourage the individual to break with tradition and bear the uncertainties involved in a new approach to lifetime planning. But it is a very demanding task to make all these things happen at once, and in trying to do so it is easy to overload local officials and the capabilities of complementary sectors. The problem is to choose just the right set of changes, sufficient to induce the proper behavioral response yet not so comprehensive as to be infeasible. The determination of the appropriate package probably involves more art and intuition than it does science. We can say that a package of changes is necessary, and identify some of its ingredients; we can warn planners not to overload the system; but the right balance and mixture cannot be specified without a large measure of intuition and judgement about specific local circumstances, much of which must be gained through experience.

Toward a Priority List. It is impossible to provide anything like a ranking of the various approaches to population policy according to their likely benefit-cost ratios. Educated guesses could be useful if additional information about specific countries were added but are of little value at a more general level. A first step in this direction can be taken, however, by considering the appropriateness of broad classes of policy options depending on the seriousness of the population problem in different countries.

In all cases, of course, countries should start with vigorous programs of family planning. In countries that do not anticipate serious problems associated with population growth, such a supply-oriented approach may be sufficient. But if population pressure is expected to be severe in the future, even though it is not today, and if there are good prospects for growth and modernization in the meantime, it would be useful to add a demand-oriented approach that tries to influence the economic development program in ways that speed up a country's transition to a low-fertility regime. The provision of more and better primary and secondary education in rural areas, especially coupled with an attempt to attract girls into the schools, measures to increase the demand for labor including female labor, the elimination of discrimination against women in labor markets, and the movement of people out of traditional agricultural areas into more modern sectors as quickly as development permits are all cases in point. It is at least as difficult to establish priorities within this area as it is to indicate how to get general development going. But it is likely that placing an emphasis on such high demographic-impact programs would alter the style and composition of development in significant ways.

As we have seen, a number of the programs that would be included in such an approach can have positive income effects on fertility in the short run; and it could take several decades before the long-run negative effects gathered sufficient strength tc offset them. If the population problem is more immediately pressing or is likely to become so before this approach has time to work, more emphasis should be placed on the use of incentives, deliberate efforts to alter preferences (using mass media and other approaches), and special projects (e.g., for women's work) that represent somewhat more direct intervention into the determinants of the family's decision-making process. If, however, the population problem is more urgent yet, creating severe short-term pressures and threatening to swamp the development program altogether, more coercive measures, such as prolonged separation of the sexes through drafts for military and work-camp service, and compulsory sterilization after the bearing of a certain number of children, may be called for. We have deliverately not considered such measures here. If we get on quickly enough with the tasks of developing and testing less draconian policies, we may hope that the number of cases in which they have to be used will be few and far between.

[Extracted from Population and Development: The Search for Selective Interventions, edited by Ronald G. Ridker, Chapter 1, pp. 1-36. Copyright©The Johns Hopkins University Press, Baltimore, Maryland, 1976.]

HOUSING FINANCE

HOUSE BUILDING IN COLOMBIA
(Photo: Inter-American Development Bank)

Housing Finance to Meet Changing Conditions

Robert H. Freed

[Methods of organizing institutions to finance housing and the repayment of mortgage loans are extremely important, both to ensure that funds are available so that houses can be built and to broaden the access of various income groups to home ownership. This article reviews a variety of such methods, indicating which ones are useful for various purposes.]

Each succeeding year, as the world's population grows and urban migration continues, the shortage of adequate housing becomes greater. It is a shortage created not from a lack of building materials, labor or know-how, but from a deficiency of financing. In order to cope with this deficiency, worldwide consideration is being given to changes in the necessary instutions and home financing methods in order to meet the needs of borrowers and lenders and enable more housing to be built.

Evolution of Institutions for Home Financing

Modern financing for homes can be said to have originated in Birmingham, England with the establishment of a building society in 1781. The first such societies had a limited number of members; loans were made one at a time to members as funds became available from the regular contributions by members and from loan repayments. When all the members had completed their homes and their repayments, the funds were returned to the members and the society disbanded. There were no interest or service charges and the loans were short-term. In 1831 the Oxford Provident Building Society was founded in the United States with 37 members. It

Mr. Freed is with the Office of Housing, U. S.
Agency for International Development,
Washington, D. C.

was terminated 10 years later and was succeeded by Oxford Provident No. 2 and then Oxford Provident No. 3. This latter society became a "serial association" in 1854 as it developed a series of separate investment clubs at short intervals, all housed together. At this point fees had to be charged for management and other expenses. Such associations were established only to finance homes and not for savings.

By the late 1800s both the English and American systems had developed into continuous associations in which anyone could deposit money and receive interest. Their role in savings was established. These early associations were mutually owned by their members who shared the profits as dividends in proportion to the funds they had on deposit. Later, stock associations were established for profit by small groups of investors.

Building societies of various types began to proliferate in many parts of Europe during the first half of this century. None of them, however, were able to mobilize the amount of savings of the British or American systems. This was generally due to the low interest rates they charged for loans, which restricted them to even lower rates paid on deposits. West Germany has been the most successful of these countries with a system of contract savings developed during the last 25 years. For example, more than half of approximately 3. 5 million public servants are building-savings contract holders. They have a fixed amount deducted from their salaries until such time as they reach a balance that qualifies them for a loan. Institutions using contractual building-savings have also been established in Latin America where they presently compete with both stock and mutual savings and loan associations.

Nearly all countries have also established governmental home financing institutions. These may be funded with general tax revenues, with special purpose funds (i. e., social security revenues), or by the sale of government notes, borrowings from abroad, foreign grants, or by some combination of each of these. They may use their funds to finance public housing programs or lend them to the institutions involved with private sector financing.

Morgage Loans

The nature of home ownership varies. In some countries this is because the land remains public and only the house and improvements may be privately owned. Elsewhere the land may be privately owned but it is leased on a long-term basis to the home owner. Both the house and land might be subject to a long-term lease. And, or course, there is the individual ownership of both.

Customarily the buyer of a house (with or without its land) needs to borrow money, and can use the house as security for loan repayment, i. e., a mortgage loan. Normally he becomes the owner unless he fails to keep up his payments. In some cases, however, the prevailing system of financing may not transfer ownership to the borrower until such time as a home loan is fully repaid. The lender may hold title to the property under a trust arrangement until the loan is paid in full, or he may hold it under a lease-purchase arrangement in which the property is technically rented until such time as all of the payments have been made to complete the purchase. (Strictly speaking, a lease-purchase agreement is not a mortgage. It is the various conditions of mortgages that we will describe here, but these variations could also be incorporated in lease-purchase arrangements.)

1. Long-Term Fixed-Rate Mortgages with Steady Payments. Since the 1930s the prevalent home mortgage in the United States has had a fixed rate of interest and repayment has been established over a fixed term of 15 to 30 years. The homeowner makes the same pre-established payment each month for the entire term, unless he chooses to make prepayments which shorten the term but do not affect the amount of the monthly payments.

2. Long-Term Variable-Rate Mortgages with Steady Payments. About the same time as Long-Term Fixed-Rate Mortgages were established in the United States, building societies in the United Kingdom established Long-Term Variable-Rate Morgages. Monthly payments were determined on the basis of the rate of interest initially charged for repayment over a given number of years. The initial interest rate was based on the cost of money to the societies, and this could go up or down with changes in the money market. The amount of the monthly payments remained constant for the life of the loan, but the terms of the loan were lengthened or shortened to accomodate interest fluctuations. An increase in interest rates would cause the repayment of the loan to cover a longer period of years. (Recently, because of the higher rates of inflation in the 1970s in the United Kingdom, many monthly payments have been changed with interest rate changes and an effort has been made to hold down the terms.)

3. Variable-Payment Mortgages: Indexation of Principal. The increasing prevalence and high rates of price inflation have led to numerous experiments with variation in the monthly mortgage payments based on changes in a price index - i. e., indexation. Inflation causes increases in both the value of houses and the prevailing interest rates, while it decreases the value of money repaid to the lender by the time he receives it. Long-term fixed-value contracts initiated when inflation was low bring losses of capital and income to lenders when it rises, and loan funds for housing can disappear. However, inflation also raises borrower incomes, allowing them to make larger monthly payments. Borrowers may well prefer to increase their payments rather than stretch out fixed payments over a longer term - which could run as

high as 60 years under the Variable-Rate Mortgage just described. Where inflation is consequential, its rate is typically highly variable. When inflation decreases unexpectedly, borrowers may suffer under fixed-value contracts made to reflect a high rate of inflation. The best way for both parties to accommodate all these risks may be to agree on a formula for indexing the monthly mortgage payments.

Indexed mortgages have been used in some parts of Europe for many years, and recently they have been adopted by many other countries in response to high inflation. Basically, these have a fixed rate of interest for the life of the mortgage, but the outstanding principal balance of the mortgage loan is changed from time to time on the basis of some index and payments are shifted accordingly. The most typically utilized index has been the consumer price index. Several countries, notably Israel, have utilized changes in the exchange rate when dealing with funds from foreign sources. The major devaluation of the Israeli pound in 1962, however, made it impossible for homeowners to maintain payments, and the system was ended. But the problem of meeting repayment schedules in foreign currency remains.

The most thorough-going and successful use of indexation has been developed in Brazil, where both the mortgage payments and the rates of interest on savings in building societies are indexed, so that the flow of loan funds is maintained. (To index only the deposit rates in savings and loan associations without indexing other financial instruments can attract too many deposits to the former at the expense of other types of savings, as occurred in Colombia.) Indexation may become highly complex when different indexes are used for different components, some of which may reflect only a fraction of the changes in value. In Argentina and Chile, for example mortgages were indexed to consumer prices, while monthly payments were tied to minimum wages and these lagged behind; this led to continuously increasing subsidy. Generally, indexing should be consistent if it is to be used.

4. Variable-Payment Mortgages: Pre-Scheduled. Where inflation is less rapid and unpredictable, borrowers and lenders may prefer to avoid the uncertainty of payment flows by establishing a fixed schedule of payments rising by a given percentage each year. This method can also be used, irrespective of inflation, to attract into the housing market young people whose incomes can be expected to increase over time. Often they cannot afford at present income the monthly payments under a fixed-payment mortgage for the kind of house they will later be able to afford; but they would be able to start paying for such a house with a mortgage that scheduled in advance a rising level of payments. These could rise along a curve, not necessarily by fixed percentage changes. This kind of schedule, under which amortization would be slow or even negative in the early years before it began to accelerate, can be calculated so that the lender's security in the value of the house (in case of default) will not fall below the amount of the debt.

This is a relatively new idea, but it is getting some preliminary trial. In 1973, on the basis of a paper by this author, the South Korean National Housing Corporation began a pilot project of 1,500 residences for which monthly mortgage payments increase by a fixed amount every six months, but with a fixed rate of interest. The State of Maryland (in the United States) has a similar pilot project, also developed by this author. Other plans in which payments are systematically increased to match expected price change, or in a direct relationship to the household's earnings, are presently under consideration.

5. Balloon Payment Mortgages. In Canada they utilize a mortgage system in which monthly payments are computed on the basis of a Long-Term Fixed-Rate mortgage. At the end of five years the borrower may pay the total outstanding balance or extend the loan for another five year period at a new rate of interest. If he chooses to extend the loan, payments are determined on the basis of the new interest rate over the balance of the original term. Each five years the process is repeated until the loan is paid in full.

Factors to be considered

It is obvious that the source and cost of money to the local lending institution play a dominant role in home financing. The amount of money available from particular sources and the limitations that are placed on its utilization may often restrict the area of choice. But, given the opportunity to choose among alternatives, a home financing program should consider the risks of future inflation, changes in family incomes, exchange rate fluctuations, potential appreciation in home values, the nature of home ownership, laws regarding delinquencies and foreclosures, and many other things. Governmental programs must carefully consider who they want to reach and what, if anything, the government is willing and able to pay to accomplish its purposes. It is clear that a type of mortgage which functions well in the absence of inflation may be totally inadequate for inflationary conditions. There is a need for special mortgages for special purposes, and especially to bring more buyers into the market.

[An original article.]

Note: This article represents the personal observations of the author, not intended as a statement of AID's policy in the field of housing.

Savings and Loan Societies for Low Income Urban Families

Georges Vernez

[Savings and loan associations specially adapted to low-income owners of self-help housing could be a significant supplement to "sites and services" programs. Guidelines are proposed.]

Housing policies for urban low-income families in underdeveloped countries have typically stressed the public supply of fully serviced "standard" housing units. Measured by the degree to which they have achieved their stated objective, these policies are and continue to be a failure. The high cost of standard housing construction coupled with extremely low effective demand by a majority of the urban population has resulted, deliberately or by default, in the retargeting of these public housing programs to the middle- and high-income minorities. Where targeted as intended the implementation of standard housing has required high public subsidies, so that it has benefited no more than 10 percent of the urban low-income population. As a result, a large proportion of the demand for shelter has been overflowing into so-called squatter settlements that are developing at the periphery of most large-sized cities of the emerging nations. These have three characteristics: 1) the incremental development over a five to fifteen year period of an individual dwelling unit from a modest minimum shelter to a multiroom, fully serviced home; 2) complete control by the builder family over the phasing, design, programming, and construction of the dwelling units; and 3) self-financing of housing construction by the dweller-builder.

Dr. Vernez, who has worked on "pirate settlements" in Bogota, Colombia, is on the research staff of RAND Corporation, Santa Monica, California.

An alternative housing policy for urban low-income families has emerged under the general form of a "sites and services" policy. [See Development Digest, July 1974, pp. 43-62.] This policy encompasses housing service delivery designed to facilitate, encourage, and accelerate the type of "self-help" incremental housing development typical of squatter settlements. The policy maintains incremental dweller control, and in varying degrees the self-financing characteristics of these housing developments. The policy should have the following complementary programs: 1) An unconventional, decentralized savings and loan mechanism designed to capture the savings of the urban low-income sector and to provide multipurpose loans targeted to this economic group. 2) A governmental land bank to facilitate access to landownership by low-income families and guide the physical growth of the metropolitan area. These would be in addition to the provision of basic public services - water, sewage, electricity and roads - and the provision of technical assistance to families involved in "self-help" housing construction, features which are more widely recognized as necessary to the sites and services policy.

The financing of construction by incremental development can benefit considerably more families than is possible by financing complete "standard" dwelling units because the former requires a lower initial investment than traditional housing. In Bogota, for example, the initial stage of construction in squatter housing requires an average investment two to five times lower than is required in minimum government subsidized dwelling units. With respect to other governmental housing programs and to commercial housing, this relationship is 30 or more times lower.

Construction by incremental development accelerates capital formation by urban low-income families. The low-income family is provided property and minimal shelter in squatter settlements much sooner than is possible in any of the other housing submarkets. Often it is their only possibility for home ownership. Investments made in the expansion and improvement of a dwelling unit accrue as captital to the family, and families also benefit from realty appreciation values stemming from rapid urban growth. Capital formation in low-income families is also accelerated because the proposed housing policy promotes investment of idle labor capacity in construction. It is widely recognized that family labor inputs to building by incremental development enable a family to capitalize 40 to 50 percent of the market value of the newly constructed or improved dwelling unit.

Benefits to the low-income family: From the point of view of the urban low-income family, home-ownership and housing construction by incremental development present several advantages. First, the family is able to maintain control over the phasing, programming, and construction of the dwelling unit so as to combine monetary and non-monetary resources - including its own labor - with contracted labor at its own economic convenience. It also fully uses the nonmonetary economic interchanges that are still a significant part of the urban low-income economy in developing countries. A second advantage is the flexibility to schedule family investments and expenditures for housing and other goods and services as preferred and necessitated by fluctuating monetary resources. In periods of hardship, the family may interrupt housing investment so as to maintain consumption of other goods, such as food and education. In periods of relative affluence, the family can increase its housing expenditures.

A Financing Mechanism for Support of Self-Help Housing

Financing of housing construction by incremental development is typically family financed without the benefit of an institutionalized credit system. An increase in these construction activities, however, will require a financing mechanism for urban low-income families. This financing mechanism should be designed to capture the savings of these families and to provide them with loans. Its design should reflect the need for relatively small investment requirements at each successive stage of housing construction, and it should take into account both monetary income instability and nonmonetary family resources in determining "ability to pay" for housing.

Ability to pay. Two factors can cause the "ability to pay" for housing to be underestimated when it is based on money income alone, as is usual in determining the eligibility for participation in public housing programs. First, this definition excludes non-monetary economic transactions, such as the exchanges of labor inputs in house construction as well as exchanges of food and other home-produced goods and services. These can often be substantial. Second, the income-eligibility criteria are based on nuclear-family resources. In developing countries, however, one should not ignore the mechanisms for income sharing and mutual help which are traditional functions of the extended family. Sociological researchers generally stress the negative role these obligations play for the economic mobility of successful members of the family, rarely recognizing the positive impact such practices have on the resources of a nuclear family. In squatter settlements one often finds families able to buy a lot and build a dwelling unit only because the necessary monetary resources have been provided by relatives.

Income instability among urban, low-income families is another structural consideration in the design of a savings and loan mechanism under a housing services policy for urban low-income families. Monthly fluctuations in disposable income may occur whenever family income is low but fixed, so that an accident may decrease income available for housing. Family income may also fluctuate because of employment instability. Various surveys in squatter settlements of Bogota indicate that one-third to one-half of family heads are occasionally employed.

Guidelines for a savings and loan mechanism: Based on these considerations, the following principles are offered as guidance to the design of a savings and loan mechanism under a housing services policy.

1. Participation in the savings and loan mechanism should include all families presently excluded from access to existing institutionalized housing finance mechanisms. There should be no minimum income limitation on participation because the monetary income of a low-income family is an unreliable indicator of family wealth.

2. No minimum or maximum saving requirements should be imposed on savings deposits. Neither should there be limiting requirements on savings withdrawals, either in time or amount. The low-income family should be serviced with flexibility according to its needs. Higher interest rates could be attached, however, to savings left during a specified minimum time period.

3. The interest rates on savings, or the dividends in the case of savings and loan cooperatives, should be equal to savings interest rates in commercial banks.

4. Perhaps the most important requirement is to relate loan value to amount saved. Such a criterion would stimulate savings, and allow use of "savings" as an indicator of "ability to pay." The loan/savings ratio should not exceed six to one. Loans should be subject to a maximum value depending on local housing material costs; loans are intended to cover housing increments, not wholly completed houses. It is likely that requests for loans will not exceed this ratio. Reportedly, the loan/savings ratio of a savings and loan cooperative in a squatter settlement of Bogota never exceeded two to one.

5. The loan amortization period may vary with the value of the loan, but should not exceed 5 years rather than the usual 20 to 30 years. Typically, amortization periods will be shorter to keep pace with the steps in construction by incremental development. Also, as an incentive for prompt and regular repayments, the amount and period of subsequent loans should depend on partial or total repayment of the initial loan. However, flexibility should be allowed on loan repayments in order to take into account income instability. No penalty should be applied to reasonable delays in payment - one to three months. Conversely, accelerated repayment of loans should be allowed.

6. As a general rule, interest on loans should be established at a rate that covers the entire capital and administration costs, as well as the effect of monetary inflation. If these mechanisms are implemented by the private sector, a normal profit rate should be added to the overall interest rate. These guidelines do not exclude the provision of subsidized interest rates for the purposes of income redistribution and

accelerating low-income housing construction by incremental development, when governments wish to make such expenditure.

7. While the savings and loan mechanism is expressly proposed to support housing construction by incremental development, its services need not be limited exclusively to loans for housing. Credit is also needed to attend to family calamities and for developing local commercial and service activities.

8. Administrative flexibility in the application of the operational criteria for savings and loans is necessary for the system to respond effectively to the needs of low- and unstable-income families. Such flexibility can be achieved only through first-hand objective knowledge of behavior and the economic and other resources of each family. This requirement suggests the need for decentralization of the savings and loan administrative mechanism at the community or barrio level. At the latter level, administrative intricacies can be minimized, periodic family economic hardship can be more easily identified, and, at the same time, community pressure can be used to avoid unnecessary loan repayment delinquency. Intimate knowledge of individual cases should reduce credit risks.

9. The form that the organizational unit at the community or barrio level can take varies by local conditions. Savings and loan cooperatives offer the advantage of minimizing administrative costs, as officers often are willing to function on a voluntary or part-time basis. Additionally, the collective interests implied in the organization structure of a cooperative make control of operations more effective. Alternative types of organization are also possible.

10. Decentralization should be limited, however, to administrative and operational functions, since a community-based revolving fund would probably be too small in some cases and too high in others. A central bank should, therefore, be established with the following functions:

a. Redistributing the capital accumulated according to the demand of the local savings and loan units;

b. Serving as a governmental insurance fund against repayment risks; and

c. Programming the distribution of government subsidies in accordance with redistribution and economic development objectives.

[Extracted from "A Housing Services Policy for Low-Income Urban Families in Developing Countries," Ekistics, No. 242, January 1976, pp. 8-13. Athens, Greece: Athens Center of Ekistics.]

Housing and Social Security in Latin America

Morris L. Sweet and
S. George Walters

[Social security funds are becoming a significant souce of housing finance for workers in some Latin American countries. The methods used in Brazil and Mexico are described.]

Since 1960 there have been major changes in Latin American housing finance, with a decline in the use of the traditional mortgage credit systems and, starting with Brazil, the creation of new national entities drawing upon social security funds. The Brazilian and Mexican programs provide prime examples of the link between social and housing.

Brazil

According to the 1960 census, 8 million dwellings, about one-half the housing stock of Brazil, were considered unfit for habitation. With the population growth, 500,000 new housing units were required to keep the shortage from growing worse. Loans for construction and homeownership, however, had reached a point where credit was obtainable only for very short periods and at extremely high interest rates. A down payment of 40 percent to 50 percent was necessary to purchase a single-family house, and the outstanding balance had to be paid within two or three years. To resolve the housing crisis, Law no. 4380 was enacted on August 21, 1964. It provided

Mr. Sweet is with New York City's City Planning Commission. Dr. Walters is Chairman, Organization and Operations Management Department, Rutgers University, Newark, New Jersey.

for the creation of the Banco Nacional de Habitaçao (BNH), which was given the task of formulating a national housing plan and finance system, and also given the sole responsibility for implementing this plan as well as the management of the entire housing finance system. The designation of a bank rather than a ministry reflected a basically financial approach to solving the critical housing problem. The legislation was designed to stimulate construction of low-cost housing and to finance the purchase of privately owned housing, particularly by lower and middle income groups. Some 60 percent of the BNH investments had to be applied to the construction of dwellings for low-income occupants.

Source of Housing Funds. BNH and the Ministry of Planning approached the problem of capitalizing the bank by involving the source of capital with the employment system of the beneficiaries of the housing program, i. e., the future occupants of low income housing. The piecemeal budget allocation was replaced in 1966 by the massive resources of the national social security fund, and savings from the national savings and loan system. The new law mandated employers to contribute an additional 8 percent of employees' salaries into a personal account for each employee held under the supervision of the Central Bank. The contribution is allocated to the Funda de Garantia de Tempo do Servico (FTGS) which is part of the social security system. It was specifically established for the retirement and unemployment benefits of employees, and its resources were made available to BNH. BNH borrows from FTGS at 5 percent, necessitating the bank to obtain at least a 5 percent return from its loans. In 1973, the bank's budget was $1. 5 billion.

There is a personal account in each employee's name; and for those employees who so prefer, the employer can hold their account in trust under the provisions of a previous labor law. Deposits for employees receive no interest for the first four years, but from the seventh year, 7 percent in guaranteed. The employee can draw upon this account only for specific reasons: 1. if the employee or member of his family is ill, 2. if he is discharged from his job and remains unemployed, 3. if he retires, or 4. if he wishes to purchase a home through the bank.

Though any Brazilian citizen can use the bank to purchase a home, its policies and operations are directed in favor of low-income families. The interest rate for homeowners' mortgages ranges from 1 percent to 10 percent, depending on gross family income. An employer willing to provide housing for his staff can obtain financing from BNH on an equal-sharing basis; his contribution is usually in the form of land.

The initial allocation of FTGS funds to BNH went to housing; they were then made available for the financing of integrated urban and local government planning, sanitation (water, sewerage, and pollution), training of technical personnel, activating industries for building materials, and construction, electricity, and highways. With the use of FTGS resources, BNH was able to establish the Brazilian Savings and

Loan System, which began to finance middle-income housing, employing the technique of seed capital to inaugurate savings associations.

Monetary Correction. Brazil has pioneered in minimizing the effects of inflation. All financial instruments except equities are pegged to inflation; mortgages are linked to wages. The usual arrangement for mortgages for low-income borrowers is to have the payment set at approximately 25 percent of salaries and, as salaries rise, payments rise accordingly. With the adjustment of the interest rate, the proportion of interest and principal per payment would vary and the amortization period of the mortgage would change.

Results. The accomplishments of BNH, of which the payroll tax is an integral part, have been impressive for a developing country. In a little less than three years after the bank started, construction of publicly aided housing units reached 500,000; in the previous 28 years, they totaled slightly less than 164,000. In its first nine years, BNH financed the building of almost 1 million homes; completion of an additional 2 million dwellings is contemplated by 1980. Some of the worst slum communities in and around major cities have been eliminated.

Unemployment has been reduced; BNH estimates that 200,000 jobs are being created annually from the construction boom, and another 800,000 workers annually obtain indirect employment benefits. In terms of housing, the most significant factor has been the additional investment in housing. "Over the four year period of January 1967 to December 1970, the Bank from this fund and through the multiplier effect of its investment on the employment situation of the country, and in particular the building industry (wherein nearly 500,000 new jobs were created in the year 1969 by BNH investment), through an intensive campaign to reintroduce the habit of savings among the people, and by the sale of real estate bonds (with guaranteed monetary correction against inflation), the BNH mobilized the equivalent of $1,500 million for investment into the housing sector of the country. Its annual budget for 1971 was in the order of approximately $1,000 million, and the system has become almost self-generating, to the extent that is is expected to increase by 12 percent each year." (Morris Judenplatz, 1972)

The accomplishments of the Brazilian financing mechanism are noteworthy, but there remain problems that should be discussed if a balanced picture is to be given. There are questions about the ability of FTGS to continue as the major source of funding for the National Housing Plan. What occurs when the fund has to fulfill its original mandate, that is, social security payments? To prepare for such a contingency, the bank undertook an extensive advertising campaign to increase savings accounts, and began by the sale of real estate bonds with the monetary correction factor to offset inflation. The importance of FTGS to the BNH is underscored by the fact that the resources secured from the fund are over twice those received from the Savings and Loan System by 1968 (see Table 1).

Table 1. National Housing Bank Resources and Obligations, Brazil, 1965-68 (thousands of U. S. dollars)

	Period to			
	1965	1966	1967	1968
Available resources				
NHB capital	28,030	43,225	62,567	82,729
FTGS	-	-	193,014	465,000
Brazilian Savings and Loan System	-	25,986	84,319	216,820
Obligations undertaken				
Induced savings	3,722	77,356	315,084	776,601
Yielded investments	25,287	142,515	787,725	1,583,450
Units, houses	19,952	57,983	228,396	398,260

Source: National Housing Bank of Brazil

Elimination of the slum communities was not done without having to face the social costs of relocation. One of the first major projects was the construction of new communities on the perimeter of the larger cities planned for the rehousing of the occupants of worst favelas (slums). In spite of dismal living conditions, many were hesitant to leave their traditional communities for sterile, lifeless homes many miles away. Yet their houses were destroyed and they were made to move, and strong feelings of resentment still persist. They frequently are uncomfortable and not adjusted to life in the poorly constructed high-rise buildings or row houses. Most of these communities are too distant from town centers; two or three hours daily are spent on travel in buses. The discontent led the bank to cancel any further forced moves. Another weakness, reflecting in part the forced moves into new housing, is the failure of many low-income borrowers to make their regular monthly payments. This points to the need for better screening of credit applicants, unless, as with the FHA in the United States, political pressures lead to a relaxing of credit standards, with a subsequent rash of defaults. [Comment: Such screening must evaluate not only conventional income criteria for credit worthiness but the desire of individuals for the move, which will affect willingness to maintain payments.]

The aforementioned difficulties are not necessarily due to defects in the underlying legislation but rather arise out of the indigenous

Brazilian political and cultural tradition and from the administration of the legislation. Adoption of the financial model by other countries should not be precluded; there has been international acclaim in respect to the Brazilian model, influencing the housing finance systems of other countries, such as Argentina, Mexico, and Ghana.

Mexico

Legislation enacted in December 1971 (effective May 1972) provided for a major program to meet the need for 2.3 million housing units through the creation of the Instituto del Fondo Nacional de la Vivienda para los Trabajadores (INFONAVIT). It is basically a banking organization with considerable autonomy, whose control is shared by workers, employers, and the federal government. Its resources come from a 5 percent payroll tax on employers. The government as an employer also contributes 5 percent of the wages for its 700,000 employees. Initial operations are financed by an interest-free loan from the government of 2,000 million pesos ($160 million). Wages of farm workers are exempt from the tax. The proceeds from the payroll tax are not considered as part of the workers' salaries, although they do receive benefits at a later time. The payment by companies is deductible for corporate income tax purposes. Firms that had ongoing programs for building or financing homes for their employees had to submit details to the fund in order to have their payroll contribution calculated. Workers in these firms had the option of asking that existing plans for furnishing housing be discontinued and that there be compliance with the new 5 percent payroll tax

A lottery system is used to decide who gets the new housing. Loans to workers are granted without any down payment, at interest as low as 4 percent, with a 10- to 20-year term, and life insurance paid by INFONAVIT. Loans can be used to construct housing, repair and enlarge existing housing, or pay off previously incurred housing indebtedness. For example, a worker earning the minimum wage may purchase a house worth 30,000 pesos (US $2,400) on an installment payment of 190 pesos per month (US $15.20); the worker with an income of 1,800 pesos per month (US $144), one worth 50,000 pesos (US $4,000) on monthly installment payments of 325 pesos per month (US $26.00). Under financing by INFONAVIT, in no case need an employee pay more than 20 percent of income for housing. First priority for this housing is given to stable families with two or more children. The preferred type of housing has an average size of $50M^2$, at the cost of some 50,000 pesos ($4,000). For the first 10 years, although the 5 percent contributions are credited to the worker's account, they are "locked in;" but at the end of the 10-year period, the program should be self-supporting, and a worker could withdraw the entire principal without any interest payment.

The plans to carry out large-scale construction to the extent of 5,000 million pesos annually ($400 million) for 100,000 low-cost housing units in both urban and rural areas are expected to have a salutary impact on employment. The 100,000 housing units should generate some 126,000 man-years of employment - 74,000 direct and 52,000 indirect. Substantial growth is expected in the construction and building materials sectors. It is estimated that, once the program is in full swing, at least 250,000 new jobs in the construction industry alone will have been created.

Results. After three years, the program set aside a total of 2,250 million pesos ($190 million) in housing credits. Over 4 million workers are enrolled in this program and 44,000 are receiving benefits directly. As of late 1973, INFONAVIT had financed the construction of 51,196 housing units, of which 13,232 were completed, 13,389 were under construction and 9,947 started; 14,626 standard model houses were completed; and it had acquired 19 million square meters of land in a number of cities for future development.

The program should have a strong economic impact on the Mexican economy. In the initial stages, it is considered potentially inflationary. But if the 5 percent payroll tax is the equivalent of a deferred wage increase, there is less immediate purchasing power for workers - that is, assuming workers do not demand pay increases, regardless of the funds set aside for them. For business firms, there are the added costs over the tax deduction features. But there is relief from any direct obligation to furnish housing to employees which could entail considerable expense.

[Extraced from Chapter 6 of Mandatory Housing Finance Programs; A Comparative International Analysis, pp. 89-102. New York: Praeger Publishers, 1976, Copyright © by Praeger Publishers, Inc. Reprinted by permission of publisher.]

CAFES ELLOUZE

INDUSTRIAL TECHNOLOGY

A SMALL COFFEE PROCESSING AND
PACKAGING PLANT IN SFAX, TUNISIA
(Photo: Kay Muldoon for IDA, World Bank)

Industrial Technology in Developing Countries: An Editorial Introduction

Gordon Donald, Editor, Development Digest

A number of development economists and other specialists are reaching the conclusion that the use of technologies developed for conditions in the industrialized, high-wage nations may often retard the growth of industrial output and employment in developing countries. Modern labor-saving machinery can be wasteful of scarce capital resources, and will generate less employment than more labor-intensive alternatives. This position is controversial: Some would argue that efficient alternatives to modern technology do not exist as a practical matter, or that they would not produce the results claimed for them. Others would stress policy problems, i. e., the difficulties of finding ways to bring about technological choices which would be more desirable.

This controversy involves questions of terminology. It has been customary to classify technologies as high (i. e., capital-intensive), low (labor-intensive), and intermediate; and some have advocated the adoption of "intermediate technology" as a general solution for developing countries. Others have objected that the best technological solutions for particular industries and countries need not be intermediate in capital intensity. (Since Western technology has been moving in a direction of capital intensity, the "highest" tend also to be the newest methods in use; intermediate alternatives are often those used in the West some years ago.) Because countries differ in their wage levels and supply of capital, what is needed is the most "appropriate technology" for a particular situation, considering all the factors involved. This terminology gets around the idea that technology must be intermediate, or any other objections that could be raised, but it gives no sense of direction.

Others would remedy this weakness by specifying "low-cost technology" as the solution: a country should choose whatever technology will produce a given product at lowest cost under its particular conditions. One objection to this approach is that prevailing prices for labor and capital may often be the source of the trouble, and they ought to be changed. The most beneficial technology would be lowest in cost after such a change, but not necessarily with existing prices. Another objection is that the cost levels of today will inevitably change, so that the low-cost alternative now may not be the lowest-cost method of the future.

Readers will find the terms intermediate, appropriate, and low-cost applied to technology in these articles. Appropriate technology, the most trouble-free term for economists, may have an unfortunate connotation when used by advisers from rich countries for application in poorer countries with aspirations for improvement. It might suggest inferiority: what is appropriate for me is not appropriate for you. The promotion of labor-intensive, old fashioned technology may seem to relegate newly industrializing nations to a low status kind of industry - or at best "intermediate" status. Complex modern machines do have status: they are the symbols and proof of progress. Those who distrust the motives of rich-country advisers may conjure up the notion of a capitalist plot, pointing to Soviet mechanization as the triumph of a formerly poor country which has marched to industrial front rank in disregard of conventional theory.

One can point out that the Russians have immense resources of iron and coal; and that the Chinese, who have much less, achieved independence from Russian advisers by developing their own labor-intensive methods. More fundamentally, the question at issue is one of the value of advice from whatever quarter for the nation using it. Industrial status symbols can be costly; they may generate rather little employment for what they cost, displacing other kinds of investment. Foreign advisers offer various kinds of guidelines, sometimes conflicting with one another, and countries must choose what they find best for their own purposes.

The first article below analyzes the wide variety of technologies used in six Indonesian industries. In the second, White assesses the evidence on the range of possible technologies that could be used in industry. Next, Pack examines policies which could bring about more appropriate technological choices. The last two present different views on how to reach the technological goal: Mendis describes how Sri Lanka is promoting indigenous and intermediate technology with cooperatives; Jequier points to the essential role of the individual entrepreneur.

Economic Man and Engineering Man

Louis T. Wells, Jr.

[A wide variety of technologies are being used at the same time within six industries in Indonesia. Analysis of managers' technical decisions and the reasons given for them indicates that many technological differences result from efforts to hold down costs in different situations, while others reflect a mixture of economic with other kinds of motives.]

One of the most perplexing problems facing a number of developing countries is that of unemployment. Industrialization, it is generally thought, has not done its share to absorb labor. It appears that the technology which is used early in the industrialization process is capital-intensive, borrowed from the advanced countries. In the opinion of many, a part of the answer to the unemployment problem is to turn to "intermediate technology," technology that involves less capital and more labor than that in general use in more advanced countries. If the businessman behaves like an "economic man" he should, according to traditional wisdom, choose an intermediate or a labor-intensive technology when operating in a less developed country with low wage rates and high capital costs. By choosing appropriately, he will minimize his costs of production and simultaneously raise employment.

Very little empirical work has been done at the firm level to examine how the businessman actually behaves. This study of technology in Indonesia is an attempt to help fill the gap. Its principal finding is that the businessman probably does not behave solely as an "economic man." Economics puts a constraint

Dr. Wells is a Professor at the Harvard Graduate School of Business Administration, Boston, Massachusetts.

on his behavior, but he may also have a rival objective as an "engineering man" which appears to influence the design of plants in less developed countries.

The Range of Technology

The first question mark about the appropriateness of the model of the economic man comes when one is confronted with the wide range of technologies that exist side by side in Indonesia. For this study, data were collected on the technology used in 43 industrial plants in Indonesia. Factories were visited in Djakarta, Bogor, Surabaya Malang, and Medan. In six industries, plastic sandals, cigarettes soft-drink bottling, bicycle and betjak tires, flashlight batteries, and woven bags, data covered four or more plants producing comparable products. In four of the six industries, there seemed to be three technologies that lent themselves to classification into "capital-intensive," "intermediate," and "labor-intensive" categories, while in two there were no really labor-intensive methods in use.

The difference in employment created under these alternative technologies is rather striking. To take the cigarette industry as an example, where calculations of the number of workers required to produce one million cigarettes per month are a common measure of automation, the employment implications are significant. In the capital-intensive class, the median of the range of number of workers required was 3; in the intermediate class, 6; in the labor-intensive class, 40. For the volume of cigarettes manufactured by the firms interviewed, this would mean 3,009 workers if all firms were using the capital-intensive technology, 6,018 if intermediate, and 40,120 if under the labor-intensive techniques. Table 1, giving crude estimates of the number of workers required for total production levels using alternative methods, shows that the choice of technology has similarly important implications for the employment in other industries. The number of plants in each group are given in parentheses.

Table 1. Number of Workers Required in Various Industries for Various Technologies (figures in parentheses are number of plants in each group)

Technology	Cigarettes	Flashlight Batteries	Soft Drinks	Tires	Woven Bags	Plastic Sandals	Total Plants
Capital-intensive	3,009(3)	464(2)	279(1)	n. a. (1)	n. a. (2)	230(2)	(11)
Intermediate	6,018(5)	1,392(2)	698(3)	1,207(4)	n. a. (2)	920(6)	(22)
Labor-intensive	40,120(3)	5,568(4)	6,417(2)	7,100(1)	-	-	(10)
Total Plants	(11)	(8)	(6)	(6)	(4)	(8)	(43)

Different Factor Costs

The range of technology observed in Indonesia is partly to be explained by market imperfections that lead different firms to have different factor costs. Each manager may be behaving as an economic man, arriving at solutions to the problem of choice of technology that are different from those of some of his competitors because of the different costs of labor and capital.

It is true that the foreigner is likely to face a lower cost of capital than the domestic firm and that eight of the eleven plants using capital intensive methods were foreign owned. In the case of the two foreign firms listed as using intermediate technology, one had plans to buy new equipment that would put it in the capital-intensive class, and both were employing secondhand equipment drawn from their factories in other countries. No foreign firms were using labor-intensive methods.

Three further bits of evidence are available to support the idea that the breadth of technology might be a response of an economic man to different labor costs. First, the foreign firms rather consistently pay higher wages than do the domestic firms, as Table 2 shows. The differences are large for both the skilled and the unskilled jobs and cannot be accounted for by differences in industry mix, location, or payment in kind. Thus, the foreign plant's choice of capital-intensive technology could result not only from access to cheaper capital, but also from the fact that the foreigner pays higher wages than the domestic enterprise.

Table 2. Wages in Rupiahs[a] per Day, by Type of Firm

Skill Level[b]	Foreign[c]	Domestic [State]	Domestic [Private]
Unskilled	314	227	123
Skilled	503	425	352

[a] One U. S. dollar equaled approximately 413 rupiahs at the time.

[b] Comparable jobs were taken in each industry. Industry by industry, the same patterns of wage differences were evident.

[c] If any of the equity was held by a foreigner, the plant was supposed to be registered with the Foreign Investment Board. This registration was the basis of classification.

The second bit of evidence comes from the subsidized "medium-term investment-credit program." Those firms that have received money at 12% annual interest under this program seem generally to have chosen a more sophisticated technology than their domestic competitors who are forced to pay the market rate of 24 to 36%. One of the three domestic firms using capital-intensive technology was financed under this program, while only three of the 20 domestic firms using intermediate technology and none of the firms using labor-intensive processes were employing this subsidized capital.

The state enterprises seem to be consistently more automated than their private counterparts. One of the domestic enterprises employing a capital-intensive process and not financed under the "medium-term investment-credit program" was state-owned. Two of the plants employing intermediate technology were state enterprises, while none of those with labor-intensive technology were owned by the government. The state enterprises may receive subsidized capital; Table 2 indicates that they face higher wage bills than their private competitors. Their choice of more sophisticated technology may be economically justified.

However, some of the typical statements of the managers of various enterprises raise questions about the simple model of the "economic man" for fully explaining the decisions that are being made.

1. After noting that machines in the process of being scrapped were capable of producing a high-quality product, one foreign manager explained the replacement of the intermediate equipment with sophisticated equipment as follows: "You have to modernize to stay ahead of the competition." This statement was made in spite of the facts that there was a ban on the import of the product and that there were no other firms manufacturing the product locally. When asked what he was going to do with the old equipment, he explained that he was going to cut it up and scrap it. He would not sell it because "some of these Indonesians can get any old equipment running."

2. Another manufacturer who was employing young girls to attach labels by hand to his products explained that he was ordering a machine to replace them. Asked whether it was cheaper to attach them by machine, he explained that he did not know, but the girls were a lot of trouble: "They just cause management problems."

3. The manager of a plant with both an automatic and a semi-automatic line explained that he was converting the semi-automatic to fully automatic as soon as possible. He wanted to produce a "high-quality product." The output of both lines was already meeting the standards of the foreign licensor and was considered among the best in Indonesia by the firm's competitors. It was not clear that further automation would improve the quality in a way that consumers would notice.

The Investment to Replace a Worker

One way of determining whether managers are behaving as classical economic men is to calculate the incremental investment made per worker saved in one level of technology compared to the next lower level.

In the choice between the labor-intensive processes and the intermediate level, the model of the economic man appears to be of some explaining the choice of technology. Unfortunately, only the cigarette and soft-drink bottling industries could be analyzed for this step. The incremental investment for machine rolling of cigarettes, compared to hand rolling, was between $50 and $120 per worker saved. For soft-drink bottling, the additional investment for semi-automatic bottling compared to hand bottling was on the order of $833 per worker saved. The wages paid out to cigarette rollers run on the order of $100 per year. Thus, even with the higher investment figure of $120 per worker, a capital cost of 36%, and a maintenance or depreciation cost of 10% per year, the annual capital cost of saving a worker is only about $55. These figures suggest that hand rolling cigarettes continues because of the cost of capital, and also because of a differentiated excise tax that favors hand-rolled cigarettes, or because the consumer prefers the hand-rolled version.

On the other hand, semi-automatic bottling may well be a poor investment for firms that must pay 36% for their capital. The annual capital and maintenance costs would be about $383, considerably above the wage rates in Indonesia. Note, though, that a foreign firm, with an 8% interest rate and the same 10% maintenance cost, would face an annual capital cost of only $150, less than the annual cost of an unskilled worker in a foreign-owned plant. It is thus perhaps not surprising that hand bottling was done by domestic producers only. Semi-automatic equipment was operated by both foreign and domestic-owned enterprises.

In the case of the choice between the intermediate technology and the capital-intensive level, the findings are rather different. Calculations could be made for critical processes in five of the six industries. The average investment per worker saved was $6,986; the range was from $2,000 to $21,500. If the foreigner is able to raise capital abroad for 8%, and the replacement and maintenance requirements amount to 10% per year (or a 10-year life for the equipment), the annual wage that would have to be saved by an economic man would, for the average $6,986 investment, have to exceed $1,260 per year. The actual annual cash wage for employees of foreign firms averaged about $225. Even with a high cost for social expenses, it is unlikely that the real costs of a worker could approach $1,260 in Indonesia, nor is it likely that wages will reach that level in the foreseeable future. At the low end, for an investment of $2,000 per worker the 18% capital costs amount to $360 per year. It is possible that the wages plus social costs of an employee for the foreign-owned plant could reach this level, but in only two industries was the investment below $3,500.

In spite of the fact that the capital costs involved in the capital-intensive technology generally far exceeded any possible wage savings, such investments were frequent and were being contemplated by many firms now using less automated techniques. The simple calculations suggest that these decisions did not make sense from the point of view of an economic man who wants to minimize costs.

Other Economic Factors

Three more complicated economic justifications for capital-intensity should be disposed of before the model of the economic man is pushed to the back seat: (1) The costs of developing more labor-intensive techniques may exceed the benefits of using known technology for the foreign firm; (2) the quality of output may not be sufficiently high or consistent with the intermediate technology; and (3) the intermediate technology may waste raw materials to an extent that their costs outweigh the benefits of the net savings on capital and labor. These themes did not, however, seem to go very far in explaining what was observed in the light manufacturing plants included in this study.

Where the intermediate technology has to be developed from scratch, or even has to be copied from others, the development costs may well outweigh the benefits to be derived from lower operating costs. One of the plants visited had attempted to introduce a new technology. After large expenditures on engineering and construction, the manager found himself with machines that did not function, and unexpected expenditures on modifications were already under way. In general, however, the managers of the plants included in this study of light manufacturing were well aware of and understood the intermediate alternative. In fact, many of the foreign firms had taken over a going enterprise as a joint venture, or had been given back a plant that had been nationalized under the Sukarno regime. In most such cases, the plant was already operating with an intermediate technology. However, in spite of the economics and knowledge of alternatives, the firms had already converted, or were in the process of converting, the plant to a more capital-intensive technology. Ignorance or cost of developing intermediate technologies was not the problem.

The quality issue is a difficult one. Engineering standards and consumer standards of quality do not always seem to agree. Quality was frequently mentioned as a reason for increased automation. However, several facts point to the conclusion that the supposed quality differences were either not real or else were not perceived by the consumer as being real. In one industry, product test data from engineering tests were available from three firms, covering the output of competitors. The products that ranked highest in level of quality and lowest in variance from this level came from manufacturers whose processes extended down into the range of intermediate technology. In other industries, I asked firms to rate the quality of competing products and compared their responses. Again, the highest agreed rankings extended well into the range of intermediate technology.

In the case of cigarettes, a rather special industry in Indonesia, the engineering standard of quality seemed to conflict directly with the preferences of a sector of the purchasers. Machine-rolled kretek cigarettes (kreteks have a special flavor, due to inclusion of cloves) were having a difficult time taking a share of the market from the hand-rolled ones. The even-burning, crackle-free characteristics of the machine-rolled seemed to be less liked by the kretek smoker than the uneven, noisy, hand-rolled variety. Machines had not been developed to reproduce the familiar irregular, flared shape of the hand-rolled variety, which seemed to be more popular with the consumer.

The labor-intensive techniques did generally result in a product that was inferior, at least by engineering standards, to that of the more capital-intensive technologies. The hand-bottled soft drinks were, for example, probably not overly hygienic. Foreign matter could easily be introduced into the bottles by accident. And flies swarmed around the ingredients before they were hand-mixed. The flashlight batteries made by the labor-intensive techniques were more subject to leakage than were the others. However, the intermediate technologies did seem capable of turning out products of a quality that was consistently as good as that of the capital-intensive techniques.

Contrary to expectations, the saving of raw material was never mentioned by the firms that were interviewed as a reason for choosing automated production processes; in fact, it appeared occasionally as a reason for not automating. The automatic looms in the bag-making plants produced more rejects than did the semi-automatic. Simple manual cutters got more sandal soles out of a piece of foam plastic than did the automatic, ganged ones. And so on. Even these somewhat more sophisticated versions of the model of the economic man seem insufficient to account for the actual choices of technology. One must look for other explanations.

Oligopoly and Capital Intensity

One impression reinforced in the interviews was that the Indonesian entrepreneur wanted as much as his foreign counterpart to have an automated plant. The suggestion was that somehow the foreign firm was in a position to fulfill this desire in more cases than was the domestic investor.

In fact, a better explanation than the nationality of firms that had chosen capital-intensive techniques seemed to lie in the degree of monopolistic advantage that the firm was able to exercise. The monopolistic position of such firms was evidenced by several factors. All but one of the foreign firms interviewed were using international trade names. The one exception had been operating in Indonesia for more than thirty years; it had developed brands that it did not use in other countries but which were thought by most consumers to be international. These brand names had given these foreign firms a position such that price was not the basis of competition. Of the three domestic firms using advanced technology, two had monopolistic positions: one was using an international trade name under license; the other was a state enterprise. In the intermediate-technology category there were only two domestic firms using international trade names. Both plants were noticeably more automated than the other domestic firms in the same industry.

Price serves as another indicator of monopoly position. The average price of the product of the capital-intensive plants was far higher than that of the intermediate level in all cases for which data were available (Table 3). Although the firms with capital-intensive technology all produce high-quality products, these products do not appear to rank higher in level of physical quality or consistency than those of the best of their

Table 3. Approximate Average Retail Price of Similar Product in Rupiahs

Technology	Plastic Sandals[1]	Cigarettes[2]	Soft Drinks[3]	Bicycle Tires[4]	Flashlight Batteries[5]
Capital-intensive	120	78	63	470	55
Intermediate	60	60	36	350	40

[1] One-piece sandals, per pair.

[2] The most popular brand, for each plant, per package of 20, white cigarettes only (excluding kreteks).

[3] For the contents of a bottle, adjusted to reflect volume.

[4] Wholesale.

[5] Size "D" (UM-1).

competitors who do not have international trade names. Their prices, though, are higher.

A further hint that monopolistic advantage, not "foreign-ness," underlies capital intensity is given by the cases of foreign firms outside the industries studied systematically. In these cases, my impression was that where trade names were not important, firms appeared to employ a much more labor-intensive technology than they used at home.

Reduction of risks. There appear to be a number of factors that drive firms toward more capital-intensive techniques than would be suggested by the simple economic models. In many cases the managers appear to want to respond to certain elements of risk and uncertainty. Capital-intensive plants seem in some instances to serve an insurance role. And some managers seem to be driven not only by simple economic objectives but also by objectives that could, perhaps, be best described as those of an "engineering man." But the ability of a manager to pay the cost of insurance against risk and uncertainty, or to let the engineering objectives have their play, is much greater for the firm that has a monopolistic position than for the one that faces severe price competition.

There are at least two kinds of insurance coverage that a capital-intensive plant might offer but the labor-intensive plant does not: the capital-intensive plant may allow the manager to respond more quickly to unexpected fluctuations in demand or to levels that are different from that for which the plant was designed; and the capital-intensive plant may be perceived as allowing the manager to reduce the risks of facing future liquidity crises.

Consider the problem of an entrepreneur who confronts a market for which the level of sales is likely to vary considerably. If the technology that minimizes costs is one that makes it difficult to adjust plant output to levels other than the optimal design output, the entrepreneur may decide not to adopt it; he may instead adopt a technology that allows for easy adjustment of output, even though it may entail a higher unit cost of production. In many cases, the more capital-intensive techniques are more readily adjusted to different levels of demand. Confronted with sporadic and unpredicted increases in demand, the manager can more easily run an added shift in an automated plant than he can in a labor-intensive plant where large numbers of additional workers will have to be recruited and trained. With brief contractions of demand, automated plants can be adjusted by running the machines more slowly, or by keeping fewer workers idle than would be the case in labor-intensive plants. Layoffs are expensive or difficult in a country such as Indonesia, where the labor laws discourage the practice.

If the insurance against errors in demand projections is attractive, perhaps the firms facing price competition should behave as the monopolists do. However, an entrepreneur faced with keen price competition is worried that his competitors may not saddle themselves with the insurance premiums in the form of higher production costs. In that case, the insured firm faces a lopsided loss-gain situation. If the original market forecasts turn out to be correct, the insured firm may be driven out of business by those not having to bear the insurance costs. At worst, the uninsured firm may miss some opportunities to profit from a quick expansion of its output. Its response, therefore, may be not to pay the insurance but to train a work force capable of producing at a level on the low side of its projected sales. On the other hand, the firm with a monopoly rent that derives from its inelastic demand curve may be able to afford the insurance. It can bear the higher production costs at the expected demand level, and supply a larger market or contract easily. And when the monopolistic firm is vertically integrated, the gains in being able to respond to an unanticipated increase in demand may be larger than is indicated by the profits of the operation under consideration.

The second kind of insurance that a more capital-intensive plant may offer is a reduction in the chances of a liquidity crisis. Managers responding to this kind of issue claimed that capital-intensive plants were "cheaper in the long run," a view which is at least partly a result of the imperfections in capital markets. Consider the possibility that a firm, confronted with monopolistic profits for a few years, fears the possibility that price competition may become so severe in the future that prices will fall close to marginal costs. Prices may actually fall to the point where they approach the marginal costs of a capital-intensive firm. The entrepreneur in Indonesia is constantly reminded of this possibility by some plants that had been closed as a result of intense price competition.

Faced with this possibility, the businessman could behave in one of at least two ways. He could build a labor-intensive plant with minimum costs and invest the incremental cash resulting from the savings during the period of relatively high prices in assets that would yield a return. If prices fell below his marginal costs later, he could close the plant, and still have an income from the assets that he obtained as a result of his lower costs during the period of high prices. But such an entrepreneur may doubt the reliability of his income from these outside investments, and in any case he is reluctant either to withdraw from his basic business or to remain in a business with a cash deficit that would have to be subsidized.

An alternative strategy would be to borrow to build a more capital-intensive plant at the beginning, pay off the loan during the period of high profits, and stay in the same business during the competitive period as long as prices remain above his low marginal costs. This strategy generally appears much more attractive than that of minimizing costs. If intense price competition becomes a reality, the entrepreneur can stay in the same business without having to make up a cash deficit. And he can avoid the risk of having to invest assets in the capital market to cover later losses. Although the second strategy appeared to be more attractive to most Indonesian businessmen, the only ones who could follow it were generally those who held a sufficiently monopolistic position so that they could bear the heavier burden of financing for the capital-intensive plant until a loan could be repaid.

Engineering Objectives. The drive toward capital-intensive technology seems also to be a response to some objectives of the "engineering man." These are:

1. Reducing operational problems to those of managing machines rather than people.

2. Producing the highest quality possible.

3. Using sophisticated machinery that is attractive to the engineer's "aesthetics."

Reducing management problems could be viewed as an economic objective if management that is freed from problems associated with people could be devoted to other money-making activities with a higher return. However, there is no reason to expect the opportunity costs of a manager of plants in an oligopolistic position to be higher than those of plants in a more competitive market. The drive appears to be only partly a response to economic opportunity costs for his time, and more a preference for dealing with mechanical rather than human problems. Similarly, the production of a high-quality product could be viewed as an economic objective so long as quality increases the sale sufficiently to offset the higher production costs. But the concept of quality appeared to go far beyond that which had a meaning to the customer. And, although variances in quality would be a major problem in the very labor-intensive technologies, it did not seem to be an issue with the intermediate techniques.

It should not come as a surprise that engineering objectives play a role in the choice of technology. After all, most plants are designed by engineers. And that engineering objectives should sometimes depart from economic objectives should also not be surprising: engineers have a training that may instill in them noneconomic values, as it clearly does in many scientists. It is worth noting that few of the Indonesian firms did any calculations to investigate the appropriate technology to employ. Most of the foreign firms required some kind of feasibility calculation before new equipment was installed, but such studies did not generally compare one technology to an alternative. The most common type of calculation was an engineering study in which the economic return was calculated only for the equipment proposed by the engineers with no comparison to alternatives. (In one case the calculations were done in the United States by a feasibility team made up of engineers who had never visited Indonesia.)

Constraints on Automation. If a firm is forced to compete on a price basis, economics provides a brake on the degree to which management can allow the engineering objectives to override the economic ones and a limit on the ability of a firm to use capital-intensive technology to insure against risk and uncertainty. Our research indicated that there are other brakes as well. The principal restraint for the firms with inelastic demand seemed to be the problem of maintaining and operating advanced equipment in a developing country. In fact, one domestic firm had installed very sophisticated machinery, but was gradually disconnecting the automatic controls as they broke down. And most of the complaints about the quality of Indonesian labor came out of the plants with the most capital-intensive technology. Maintenance and operation of the sophisticated equipment were requiring scarce skills.

The labor laws appeared to provide some brake for firms already in operation. A few managers explained that they had firm plans to automate, but could not do so immediately because they were not allowed by the government to release the workers made redundant. As soon as natural attrition of workers enabled them to do so, they would proceed to a more sophisticated technology.

And for some of the very labor-intensive firms, the inability to raise capital at any price seemed to act as a brake on moving to intermediate technology. Some were unable to borrow from the state banks and did not have the contacts to raise money on the quasi-legal private money market. What from the private economic view looked like an attractive movement up the scale of technology was constrained by the unavailability of the required capital at almost any price.

Conclusions

This study has only begun to probe the complex factors that influence the manager in his choice of technologies. The simple combination of production functions and factor costs is clearly inadequate to the task. A surprisingly wide range of technology was found to exist within the same industry and country. The capital-intensive techniques were generally associated with foreign investors. However, they seem to be more closely associated with investors who had some monopolistic position. Foreigners happened to be in such a position more frequently than domestic investors, but the drive toward capital-intensive plants seemed to be similar among both foreign and domestic managers.

The managers' choice of technology appears to be influenced by two objectives which, in low-wage countries, are generally conflicting. The first objective, that of the "economic man," is to minimize costs. This leads to a relatively labor-intensive production process. On the other hand, the objective of the "engineering man" tends to lead toward more sophisticated, automated technology. Where price competition is the rule, the objectives of the economic man seem to override those of the engineering man. But when the firm has a monopolistic advantage, there is less pressure on the firm to minimize costs to survive; the goals of the engineering man are allowed to move the firm to a level of technology that is more advanced than that which the economic man would choose. In more advanced countries, however, there may be little conflict between the economic and the engineering objectives.

[Extracted from "The Economic Man and the Engineering Man: Choice of Technology in a Low-Wage Country," The Choice of Technology in Developing Countries (some cautionary tales), by C. Peter Timmer, John Woodward Thomas, Louis T. Wells, Jr., and David Morowitz. Harvard Studies in International Affairs, Number 32. Cambridge, Mass., Center for International Affairs, 1975, Copyright © the President and Fellows of Harvard College. (Note: copies may be obtained from the Center for International Affairs, 6 Divinity Ave., Cambridge, Mass. 02138, U.S.A., price $3.95.) Another version of this article appeared in Public Policy, Vol. XXI No. 3, Summer 1973.]

Factor Proportions for Manufacturing in Less Developed Countries: A Survey of the Evidence

Lawrence J. White

[In the debate over the desirability of more labor-intensive technologies for use in industry in low-wage countries, an important question is whether efficient alternatives to the technologies used in high-wage countries are actually available. This extract reviews a range of evidence on the subject, concluding that efficient alternatives can very often be found.]

The question of appropriate factor proportions in LDCs has emerged as one of the most important development problems of the 1970s. High and rising rates of unemployment in urban areas pose major political and economic problems for less developed countries (LDCs). Simultaneously, employment in manufacturing is frequently growing far more slowly than the growth of manufacturing output. The high capital intensity of LDC manufacturing is frequently cited as the cause of these phenomena. Capital-labor ratios for new or proposed industrial projects in LDCs are frequently $15,000 or more per worker, and facilities in the petrochemical industry can run as high as $200,000 per worker. The following questions must be asked about these high capital-labor ratios in LDC manufacturing: Are they necessary? Or are there efficient alternatives which use less capital per worker and could therefore be more appropriate for LDCs? What evidence is available on this point? This paper will provide a non-technical review of the available evidence that can shed light on these questions. A dozen surveys or summaries that deal with the problem of technology for LDCs have appeared since 1970 [references to these and other works are found in the original paper]. But the emphasis of each is somewhat different, and none has focused primarily on the evidence concerning

Dr. White is Associate Professor of Economics, Graduate School of Business Administration, New York University, New York City.

factor proportions and appropriate technologies in manufacturing, which is the major task of this paper.

It may be useful to illustrate the direct effect of high capital-labor ratios for new manufacturing projects. Let us suppose that an LDC has a per capita income of $500. The country has a current population of 1,000 (for easy computation) and a labor force of 400 growing at 3% per year, so that 12 new workers are added. Current GNP is $500,000. If the country is investing 18% of GNP, perhaps 12% - i.e., $60,000 - would be available for net new investment (the remainder covering the replacement of older, worn-out capital.) Average capital per worker in the entire economy might be $1,000.

Now suppose that new manufacturing projects require a high capital labor ratio -- say, $15,000 per worker. The available investment funds would only stretch as far as equipping four new workers; i.e., only one-third of the new workers would be equipped; the remainder would have no capital with which they could work and presumably would be unemployed. If we were to equip the new workers at the prevailing $1,000 capital per worker level, we would have funds remaining for investment; these could provide only three and one-half workers with the capital intensive manufacturing jobs. Thus, if unduly capital-intensive manufacturing processes are chosen, not only will capital deepening fail to take place among almost all the existing labor force, but a small industrial labor elite will develop. However, if there were efficient technological alternatives with lower capital/worker ratios, so that the new investment could be more widely spread over the entire labor force, overall output and income would be higher than with the capital-intensive methods because of the diminishing marginal productivity of capital when it is all concentrated on a few workers. Thus, though the high productivity from high capital-labor ratios is the eventual goal of economic development the efficient path to this goal is a gradual capital deepening for all rather than sharp capital deepening for a few.

High capital-labor ratios, then, clearly pose serious economic and social problems. But are there efficient alternatives, or are the high ratios a problem that LDCs must live with until alternative technologies are devised?

Alternative Factor Proportions: The Evidence

The belief that capital intensive manufacturing processes similar to those found in developed countries are the correct ones for LDCs appears to have been very strong in the 1950s and 1960s, especially by engineers but also by a number of economists. The major argument in favor of them was that they were simply more efficient than more labor intensive alternatives: the latter, it was claimed, would always use more labor and more capital per unit of output than would the process with the high capital-labor ratio. Thus, though alternatives might exist in a technical sense, they would always be found to be inferior. This could also be characterized as a belief in fixed proportions (as opposed to factor substitutability), since the efficient factor combination is fixed at the proportions found in developed countries. The identification of efficiency with "productivity" (i. e., labor productivity) by many international study groups and productivity missions in the 1950s and 1960s has contributed to this view. This confusion of labor productivity with efficiency meant that high capital-labor ratios would be associated with efficiency.

Some writers, like Jack Baranson (1969, 1972) and W. Paul Strassman, (1968), have argued that high levels of mechanization are necessary to ensure high levels of quality (e. g., in machined products), or to substitute for managerial skills in organizing and supervising workers -- skills which are even in shorter supply in most LDCs than is capital (Albert O. Hirschman, 1958). A completely different line of argument favoring capital intensive technologies has rested on alleged saving and reinvestment rates by different economic groups. As argued by Galenson and Leibenstein, capital intensive technologies would mean higher returns to capital, and capital owners have higher saving and re-investment rates than workers. Hence, even where efficient labor intensive methods are available, capital intensive methods should be chosen because reinvestment would be greater and the pace of industrialization would proceed faster. This argument clearly hinges on empirical evidence concerning savings rates by different groups.

We now turn to the evidence. In one sense, it is easy to provide evidence that developed country capital-labor ratios are not the only alternatives available. A glance at any LDC industrial census with capital data will reveal capital-labor ratios that are usually a third of those in the U. S., and this despite the prevalence of LDC rates of capacity utilization below that found in the U. S. (i. e., LDC capital-labor ratios would be still lower with better capacity utilization). But the believers in the superior efficiency of capital intensive methods would probably not be convinced by this kind of evidence. They might well argue that the LDC methods are inefficient (antiquated, improperly conceived), and that protectionist policies in LDCs buffer these inefficient production units from more efficient competition. They might also argue that the LDC methods are efficient only for the small size of LDC markets, and that larger volumes could be produced more efficiently with more capital intensive methods - an argument to which we shall return below. Accordingly, a more systematic investigation than just a casual perusal of LDC industrial censuses is needed. We shall discuss six different kinds of evidence.

Econometric investigations of factor substitution. There have been a large number of efforts to use LDC data, usually from industrial censuses, to try to measure the degree of substitutability between capital and labor. All such efforts involve trying to measure the elasticity of substitution (i. e., the percentage change in the capital-labor ratio in response to a change in the factor-price ratio) in a constant-elasticity-of-substitution (CES) production function involving capital and labor. An indirect method is used: if the logarithm of output per worker is regressed against the logarithm of the wage, the coefficient on the latter variable is an estimate of the elasticity of substitution. Most studies use this form. A few regress the output-capital ratio against the return to capital, or the capital-labor ratio against the wage alone, or the ratio of the wage to the return to capital (all in logarithms) to provide alternative estimates. These estimates have been made for the whole of manufacturing in single countries and for individual sectors within manufacturing, for both time series and cross-sections, and for sectors across different countries. There have been some 53 empirical studies, largely in the 1970s, covering a wide variety of countries.

It is difficult to characterize the results of these studies. The estimates of the elasticity of substitution are, with only a few exceptions, positive, indicating (if one accepts the methodology as valid) that efficient factor substitutability is possible and that the fixed proportions view of the world is incorrect. The estimates tend to clump between 0. 5 and 1. 2, but some studies find values appreciably above and below these values. Cross-section studies tend to find higher elasticities than do time series studies. An elasticity above 1. 0 implies that not only will a fall in wages induce an increase in employment (as labor is substituted for capital) but also that labor's share of income will increase.

The problems are that: the data are bad; the CES form may not be the correct one; the time series studies may not include lags properly; the profit maximization assumption may not be a good one; the assumption of competitive markets is surely not true; the cross-country studies may not use the correct exchange rates; the cross-section observations may not be using comparable industries; the level of capacity utilization is usually not held constant; all labor and all capital are assumed to be uniform and to be the only factors of production; and so on. It is easy to be skeptical of the results. Howard Pack (1972), for example, has argued that rather than showing a causality between substitution away from labor and wages, the regressions may be showing a reverse causality between wages and increasing productivity. Cross section regressions may be capturing a similar effect, as could the regressions using capital-labor ratios. In any case, there is little consistency among the cross section studies in their rankings of common industries by estimated elasticity of substitution. If one already believes that capital-labor ratios are efficiently flexible and that entrepreneurs do respond to factor price incentives, then the results of regression equations do provide support for this view. But if one believes that efficient factor proportions are more or less fixed, then the regressions may not support the claim of substitutability.

Engineering or process analysis studies. In these kinds of studies, researchers investigate individual manufacturing processes or individual products. The investigators usually use engineering or other technical information to determine the inputs necessary to produce a given volume of products or to process a given volume of manufactured items. A principal part of the investigation is to see if there are alternative means of producing that same volume; i. e., if more workers and fewer machines (or, more usually, simpler and cheaper machines) can produce the same volume as fewer workers and more machines. Twenty-two such studies can be cited.

An important result does emerge from these studies: factor substitutability does seem to be quite possible, and the differences in factor ratios can be quite substantial. Timmer's (1975) study of rice milling and marketing systems found four efficient alternatives, of which the most capital intensive required $65,000 investment per worker and the most labor intensive $700 per worker. The ECLA study of cotton textiles reported by UNIDO (1969) showed a choice of efficient techniques ranging from $6,600 investment per worker to $21,500 investment per worker; Pack's (1974) study argues that the lower limit is closer to $1,000 per worker. Further, Pack (1974) was able to relate the efficient factor combinations observed in operation to the wage rates and returns on capital, to calculate elasticities of substitution. Of six industries observed all had positive elasticities of substitution, and five were above 1.0. In virtually all these cases, the labor intensive or intermediate alternatives are economically superior at realistic opportunity-cost wage and interest rates for LDCs. Thus LDCs do not appear to be limited to current developed-country capital intensive methods.

There are some unanswered questions, however. First, the question of economies of scale: some studies find appreciable economies of scale in metal machining processes and in cement block making, and that capital intensive methods are necessary to capture these economies. At low volumes there are efficient labor intensive alternatives, but as volumes increase the input levels grow more slowly, so that unit costs fall; and this happens to a greater degree for capital intensive processes. At very high volumes the capital intensive processes dominate, so that at any wage or interest rate it makes economic sense to choose the capital intensive processes. The lower the wage, however, the higher the volume at which it makes sense to switch from the labor intensive to the capital intensive processes.

Economies of scale are particularly important for certain manufacturing processes like metal finishing, and in flow processes which involve liquids, pipes, and containers, like petroleum refining and chemical production. The importance of setting-up costs for a production run, or the surface area and volume relationship of containers, dominate here. For other types of manufacturing process, and certainly in materials movement between processes or into storage, the scale effects seem to be much less important. Clearly, much more needs to be specified in the relationship between scale and factor substitutability in order to distinguish processes in which capital intensity is genuinely cost-saving with particular factor prices from those where it is not and to distinguish what combinations of these are possible in the same operation.

For a product that does embody significant scale effects, LDCs face a dilemma. The small-market LDC can achieve appropriate factor proportions but has high unit costs (although it would have still higher unit costs if it switched to the capital intensive method), while the large-market LDC can obtain lower unit costs but with high capital intensity. Only research leading to new technologies that would decrease the importance of scale effects or have them apply equally to labor intensive methods offers a way out of this dilemma.

A second open question in these studies is the problem of quality. Are capital intensive processes necessary to ensure high quality? Frances Stewart (1975) argues that this is the dase for cement blocks, while other studies claim that quality need not be affected by technique or neglect to mention the problem. Levels of desirable quality, of course, vary with the market requirements. As noted above, other observers argue that, particularly in metal finishing processes, machines can substitute for skilled labor and foreman supervision for ensuring a high, uniform quality standard. Unfortunately, there is only one piece of quantitative evidence on this point. Christopher Clague's (1970) study showed that the overall efficiency of Peruvian industries relative to that of comparable U. S. industries increased as capital intensity increased: machine paced processes seem to offer less latitude for labor inefficiency. The engineering and process studies have not thus far been able to quantify this, and so it must remain, with the exception of Clague's study, largely an open question. It should be noted that high levels of mechanization will require the repair skills necessary to maintain the complex modern machinery, and these are usually as scarce in LDCs as the management skills that the machines are supposed to replace. Repair skills to handle simpler machinery, however, are ususally in greater supply.

In all, the engineering and process analysis studies do provide powerful demonstrations of the feasibility of labor intensive methods and are probably more convincing than the econometric studies on substitutability. But there are still the difficult questions of scale, quality, and skill substitution that merit further study.

Anecdotal evidence. Under this category we group studies that report examples of labor-capital substitution but do not offer precisely quantified estimates of efficient combination in the way that the engineering studies do. These reports can nevertheless offer useful insights in the production processes.

During Japan's early industrialization, for example, when wages were comparatively low, machinery in textiles and other industries were run faster and with extra shifts; this meant more frequent halts for repair, but repair was a labor intensive activity. The overall effect was greater labor intensity and greater efficiency in the use of all resources. Thus, even for processes in which mechanization was necessary for quality reasons, double and triple shifts greatly decreased the overall capital-labor ratio. Much use was made of older, used equipment from the West. Raw material inputs were modified so that more labor intensive processes could be used. Gustav Ranis reports that similar capital-stretching, labor intensive techniques are now being used in Korea and Taiwan in textiles, electronics, woodworking, and other industries. He further points out that even for products in which there may be technical rigidity in some main production processes, there are always peripheral processes like materials handling and packaging which can be done efficiently with labor intensive methods. Similarly, Howard Pack (1972; 1976) reports examples of labor-capital substitution in consumer goods manufacturing in Kenya, but also notes quality problems: for example, human handling of fruit inputs into food manufacturing may lead to higher rates of spoilage or breakage.

A number of other reports describe LDC production processes that are more labor intensive than those of developed countries. But are the adaptations efficient? In virtually all cases, the researchers state that greater labor intensity has taken place in response to the lower volumes and/or the lower wages of the LDCs. This kind of response does tend to support the notion that these are efficient adaptations. The anecdotal evidence then, points in the same direction as the earlier evidence: greater labor intensity is not only feasible but is in fact occurring in some LDCs. It does, however, seem to be closely tied to good management.

Big firms versus small firms. It is widely acknowledged that small firms are more labor intensive than large firms. But are the small firm more efficient? The output-capital ratio of the small firms compared to the large firms is critical to deciding whether capital can be saved by expansion of small firm production. The evidence is mixed: Gustav Ranis (1962) finds that small firms in Pakistan had higher capital-output ratios than large firms; B. V. Mehta (1969) finds the same to be true for India, as does Keith Marsden (1969) for a number of countries. But P. N. Dhar and H. R. Lydall (1961) find the opposite to be true for India, as does J. C. Sandesara (1966; 1969). [This subject is also addressed in the next article.]

Used machinery. Second-hand machinery from high wage countries is frequently recommended as a way for LDCs to reduce capital-labor ratios. A high wage economy will find it economically rational to replace machinery much sooner than would a low wage economy when new and more labor-saving models are developed, and when capital is cheaper and more abundant. Low wage LDCs should find worthwhile the purchase of used machines that developed countries find marginal. If there is an active market in used machinery in the developed country, the price of the used machine would have to fall by enough for buyers in that country to find it worthwhile to consider the used machine as an economic alternative to the new machine. At such a price an LDC buyer will surely find the machine more worthwhile, even with transportation cost added, because of the latter's lower wage costs. The counter arguments are that good markets in used machines do not exist, that used machines are a very risky proposition, that spare parts may not be available, or that the machinery is so technologically obsolete that the use of the machines is inefficient compared to new machines.

What is the evidence? First, it should be noted that organized markets in used machinery are present in the developed countries. Brokers, catalogues, and trade associations of used machinery dealers do exist. Second, over half a dozen studies supply a fair amount of evidence that used machinery is employed efficiently in LDCs. C. Cooper and R. Kaplinsky (1975) do stress the risk element in buying used machines; it takes special skills to be able to tell which ones are the "lemons," and manufacturers' warranties will no longer apply. Indeed, all of the studies stress the need for good management and engineering skills as a necessary adjunct to the proper choosing, adaptation, and use of second hand machinery.

There is a particular advantage which could be gained by buying second hand motor vehicles. There are large stocks of used cars and trucks constantly available for sale in the U.S. and Europe. It is well known that, especially for cars, prices depreciate faster than pure utilitarian usage considerations would dictate. Spare parts are usually quite available, and technological change since World War II has been quite slow. It would appear that many LDCs would do well to forego importing new vehicles or attempting the domestic production of these vehicles and instead to import large quantities of used vehicles. Repair requirements would be greater for a fleet of used vehicles, but these skills are present in most LDCs. Parts, if not available, could be manufactured locally. Both domestic and foreign exchange resources would be saved for better uses. In sum, the evidence on used machinery does show the possibilities of lower capital-labor ratios.

Multinational Corporations (MNCs). The MNCs are frequently pictured as the special villains of the appropriate technology effort. They are, so the argument goes (C. Vaitsos, 1975; Paul Streeten, 1973), tied to their capital intensive technology in the developed countries. That is what they are familiar with; that is what their product quality and trademark image is frequently based on. It is frequently too risky and costly for them to try to change their technolgy for LDC conditions. They ignore the possibilities of using local raw materials inputs. And, even if they were considering adaptations, they frequently pay higher wages than do locally-owned firms and they can obtain their capital abroad at cheaper rates, so they would have less incentive to adapt. The counter argument, presented by Howard Pack (1972; 1976), is that good management appears to be necessary to recognize and utilize the possibilities of labor-capital substitution. And the MNCs frequently have the best management around; even if they pay higher wages than local firms, their wages are still considerably lower than those in the home country so that there is a strong incentive for adaptation.

What is the evidence? Here we must be very careful in evaluating it. A number of interview and questionnaire surveys of MNCs have concluded that only a modest amount of technological adaptation has taken place, and that has been mostly in response to lower volumes, not local factor costs. This evidence has been widely cited by those who see the MNCs as villains. But there is an interesting paragraph in Gerard K. Boon (1975) describing an interview at an engine plant owned by an MNC in Mexico. At the beginning of the interview, the management assures Boon that the Mexican plant uses exactly the same technology as that used in the parent plant in the developed country. But as the interview proceeds and Boon tours the factory, it becomes clear that in many respects the factor proportions are different. The main machinery processes are automated but second-hand equipment is used, and all of the packaging, handling, transporting and storing are done much more labor intensively. Perhaps interviewers get told what the interviewees think they wish to hear or what the interviewees wish to believe!

Contrary to these interview or mailed questionnaire surveys, it appears that any researcher who sticks his head into an MNC facility in an LDC and looks around is likely to find substantial adaptations of capital-labor ratios, particularly in auxiliary processes. More than a dozen studies find MNCs adapting to labor-intensive processes for export processes. Not all MNCs adapt: some of the MNCs in Paul Strassmann's sample (1968), for example, had not adapted their technology. But a higher fraction of the MNCs in this sample adapted their technology than did locally owned firms, and a higher fraction were using second-hand machinery.

It appears, then, that both locally controlled firms and MNCs can and do adapt their factor proportions. But which group is more likely to adopt the more labor-intensive methods? In examining comparative evidence, we cannot consider economy-wide comparisons: MNCs are always more capital intensive than local firms since they do have a comparative advantage in capital intensive products. The critical question concerns comparisons within an industry in which both groups are present. Strassman, Pack, and the ILO mission to Kenya all find the MNCs to be more labor intensive; they explain this on good management grounds. But R. H. Mason (1970;1973) finds that for a group of matched pairs of firms, U. S. controlled firms tend to be somewhat more capital-intensive than locally owned Philippino or Colombian firms; and G. M. Radhu finds foreign firms to be more capital intensive than locally owned Pakistani firms. Benjamin H. Cohen (1973; 1975) finds no significant differences between foreign and Korean firms producing for export markets. The evidence is clearly mixed. While the MNCs may not be the heroes of appropriate technology, they appear to be far from the villains that many make them out to be.

Factor proportions and saving rates. An argument cited earlier in favor of capital intensive methods is that they would raise the income share of capital owners, who are supposed to have higher rates of saving and reinvestment than do workers; the pace of industrialization would thereby be quickened. This kind of argument, of course, presupposes that government taxation of labor incomes for saving purposes is not feasible. But, ignoring this, what do we know about savings rates?

The evidence reviewed by Raymond R. Mikesell and James E. Zinser (1973) does indicate that saving out of labor income is very low; the marginal propensity to save rises with income, and the saving rate out of profits is high. But if we turn to the savings rates of firms of different capital intensities, Gustav Ranis (1962) provides evidence that medium size (less capital intensive) firms have higher saving and reinvestment rates per unit of output than do large firms. V. Appavadharrlu (1974) argues that small firms in India have higher saving rates than large firms. firms.

This extract has summarized the available literature on the possibilities of labor-capital substitution in LDC manufacturing. Each section has presented one aspect of the evidence. By itself each section may not appear entirely convincing, but together they do paint a rather impressive picture. There do seem to be plenty of opportunities for more labor intensive methods to be used. But the ranges of choice are far from complete. It is the task of research and development to increase the range of choice.

[Extracted from Attachment C to Proposal for a Program in Appropriate Technology, pp. 1 - 36. Submitted by the U. S. Agency for International Development to the U. S. Congress, June 30, 1976.]

Policies to Encourage the Use of Intermediate Technology

Howard Pack

[Given that more labor-intensive technologies would be desirable in the industries of developing countries, how can this be brought about? This article argues that government policies which have fostered capital-intensity will need to be modified, and proposes some methods that could have this result.]

This paper has several purposes: to indicate the policies by which a government may alter the relative costs of capital and labor in industry; to indicate how much is known empirically about the efficacy of such changes; and finally, to consider how a program to undertake such changes can be pursued.

The focus on this kind of policy change for less developed countries (LDCs) assumes that, if factor prices were changed, then methods of production could be introduced which are more labor intensive than those currently in use, and which will be more profitable at the new factor prices than techniques currently in use. This assumption rests on the following research findings [see also preceding article].

In a large number of industries a product is producible with a considerable range of alternate ratios of capital to labor. Much of the potential substitution of labor for capital stems from use of labor intensive methods to transport material within the factory, to pack cartons, and store the final product - i. e., in peripheral activities. Evidence is accumulating that the core production process itself also offers efficient possibilities for using less expensive equipment, and more labor per unit of output. Adaption of existing equipment, for example by increasing the normal speed of operation, offers further opportu-

Dr. Pack is professor of economics at
Swarthmore College, Swarthmore, Pennsylvania.

nities to save capital and increase the relative use of labor. Finally, the extensive under-utilization of industrial capacity provides scope for raising effective labor/capital ratios by increased utilization. Some industries, however, seem to offer little possibility for altering the capital/labor ratio from that prevalent in advanced economies; these are typically activities in which most LDCs have no comparative advantage.

The Role of Factor Prices

Competitive Environment. The ratio of labor to capital costs is usually thought to play a decisive role in determining the ratio of capital to labor used in the production process. This role of relative factor prices, however, requires competition among producers to be effective. There is abundant anecdotal and some numerical evidence which suggests that factor prices have rather little effect in non-competitive environments. A monopolistic firm currently realizing a 30 percent return on its equity capital, though using an inappropriately high ratio of capital to labor, may have little incentive to search for more appropriate methods which may raise its return to 35 percent. If factor prices are to exert pressure toward adopting socially appropriate techniques, some kinds of competitive forces must be present. In some of the small markets in LDCs, such pressures may be best engendered by international competition rather than by a proliferation of large numbers of small domestic companies when none of these are likely to reach economically efficient sizes. In other cases, increased numbers of efficient small producers may be the best solution.

Factor Price "Distortions". It has become conventional to assert that labor costs in LDCs are "too high," capital costs "too low," and raw materials prices distorted, though not in one direction. What is the precise meaning of these statements?

The hiring of a worker entails the payment of a cash wage, and one or more of the following: payments in kind (housing), non-cash fringe benefits (social security), and in some countries such supplements as "thirteenth month" salary. The cost of hiring a worker is "too" high if the value of the cash wage and other benefits exceeds the income which the worker could command elsewhere, given his abilities, both inherited and obtained by education and on-the-job experience. It has long been noted that the typical employee in a modern enterprise, be it a factory, bank office, or government agency, earns considerably more than a worker in small scale artisan shops or in self-employment such as barbering, and certainly more than agricultural workers and small farmers. It is generally believed that the observed income differentials do not represent a reward for greater productive ability, but are artificially high and institutionally supported, reflecting government minimum wage legislation, union bargaining success, and employer aversion to paying lower, more appropriate wages which typify other activities. There have been no studies measuring the extent to which such high wage incomes are the result of greater work-related skills; although recipients of high wages are often unskilled when initially hired, their productivity can increase by learning on the job. But even if some of the observed high wage structure is related to skills, it is likely that union pressure and government minimum wage legislation add to these differentials.

The statement that wages are too high thus refers to the norm of alternate income possibilities for a similarly skilled worker, either in the urban craft sector or in rural activities. It does not imply that these wages are excessive in comparison with those in developed countries, or that such workers are able to afford a luxurious living standard. But high wages accruing to the small group lucky enough to obtain modern sector jobs do imply that production will be undertaken with fewer workers than if wages were lower, thus condemning those not fortunate enough to obtain such jobs to a lower standard of living than would have been possible with a generally lower wage structure. Instead of a million workers employed in the modern sector, each receiving a wage of $500 per annum, 200,000 workers may receive a wage of $900, with the remaining workers earning $150 per annum.

The cost of plant and equipment reflects the purchase price of a factory building or machine, and the costs incurred in financing it. The cost of using plant or equipment is best viewed in terms of a firm's annual expenditure: depreciation of the initial acquisition cost; and a yearly financing charge incurred as the result of a decision to purchase the capital item. The purchase cost of equipment is too low in most LDCs in the sense that the net effect of government foreign trade policies is typically to artificially lower the amount of domestic currency which must be given up to pay for an imported machine. Most LDCs have engaged in a sustained import substitution program, one of whose characteristics is to maintain an overvalued exchange rate, i. e., the domestic currency buys too much foreign currency. This artificial cheapening of foreign goods may be offset by high tariffs on imported goods which compete with domestically produced goods. However, no tariff is imposed on imported equipment, in order to encourage domestic investment. Thus, LDC firms purchasing new equipment pay a lower price than would exist if governments did not discriminate between different types of imported goods. A low purchase price, of course, is reflected in low annual depreciation charges.

The second major cost is the financing charge. Financing of investments may originate either in bank loans or in funds from private sources. The interest charges paid by larger companies in the urban sector is too low as a result of governmentally imposed limitations on bank rates of interest. At these low-ceiling levels of rates, the total demand for loanable funds exceeds the supply, and the existing supply is rationed among competing companies, none of whom are charged more than the legal maximum. Companies which are unsuccessful in this competition are forced to borrow in a private market in which the rates often are three or four times the official one. The financing charge for new equipment or buildings will clearly be greater for those (usually small) firms which cannot qualify for bank loans. When they are willing to borrow at these rates, this suggests that profitability in their industry is at least equal to this higher rate. Large firms, receiving as it were subsidized loans, pay too low an annual financing charge for the capital which they use.

Apart from low purchase prices and interest rates for many investors, numerous tax regulations further reduce the annual charge for using equipment. For example, investment credits and accelerated depreciation are likely to have adverse effects on the choice of production methods, particularly in view of the already high rates of return being earned by investors who hardly require additional incentives.

The cumulative effect of all these distortions in wages and the cost of capital has presumably been to bias the choice of individual firms toward unnecessarily capital intensive production methods. One indication of this is the discrepancy which has been observed between the growth of output and of employment in the industrial sector. Considering the continuing large flow of new equipment from industrialized countries to LDCs, some of this must be inappropriate given the high wage levels in the former countries for which the equipment is presumably appropriate.

To remove the incentives toward adoption of socially inappropriate equipment, the imperfections in factor markets must be reduced. The following policies would have this effect: 1) Removal of the minimum wage, particularly for new employees, or reducing it to the levels prevailing in the craft sector. 2) Undertaking policies to shift the supply curve of wage goods in order to reduce their price. 3) Limiting the growth of wages paid by the government sector, which often serve as a guidepost for private sector wages. 4) Curtailing the fringe benefits such as social security currently in force. 5) Allowing the official exchange rate to move down towards its equilibrium value and removing tariffs, administrative limits on imports and so on. Alternately, and less desirably, tariffs on imported capital goods could be introduced to raise their cost in domestic currency. 6) Removal of interest rate ceilings. 7) Elimination of tax incentives which reduce the cost of utilizing capital in production. 8) Elimination of the licensing of imported raw materials, a practice which has often been shown to discriminate against small labor intensive enterprises.

It would be difficult to construct a set of policy proposals which would generate more intense opposition among many of the most politically powerful groups who perceive the probability of substantial reductions in income. Highly paid, often unionized workers concentrated in urban areas would be adversely affected. The management of large companies currently enjoying subsidized equipment, low interest rates and access to raw materials would have to contemplate a reduction in windfall profits. Those who would benefit most, the workers and entrepreneurs in the craft and small scale sectors, while surely more numerous, are poorly organized and likely to be less politically active. It is easy to see why such alterations in factor prices, even where the potential overall benefits are understood by the government, may not be attractive to it.

A more immediate question is whether factor price changes will work. Changes in technique are most easily made when new production decisions are taken. Existing equipment usually has limited flexibility, not permitting a decrease in the capital/labor ratio. Will firms facing a changed economic environment actually react in the anticipated direction when expanding their capacity?

First, unless a reasonably competitive environment exists, the rates of return available in highly protected industries may be such that little effort is forthcoming to adjust factor proportions. Small increments to profit resulting from economizing on inputs may not be worth the effort as long as "reasonable" profitability can be maintained. Even assuming a desire to restore or augment profits, managerial time may better be spent cajoling a somewhat higher nominal protection rate for a firm's output, looser quotas on critical inputs, etc., than in adjusting factor proportions. Avenues to increased profitability other than improved productive efficiency must be closed if changes in factor prices are to provide the strongest possible impetus to an exploration of alternate techniques of production.

Secondly, it is possible that despite the objective existence of more labor intensive production methods, this knowledge is not widely diffused among entrepreneurs. Knowledge of appropriate techniques requires familiarity with a number of different kinds of basic production equipment, and with alternate methods for carrying out subsidiary operations such as intraplant movement of material. However, these alternatives are not likely to be advocated by the (large) company's engineer, by the equipment salesman, nor by government agencies.

Evidence on the Effects of Changes in Factor Prices.

There have been only a few conscious attempts by LDC governments to alter relative factor prices. The classic success stories of appropriate factor price policies associated with a sustained growth in industrial employment are in South Korea, Taiwan and Singapore. In the first two, the interest rates charged by public and private banks were raised sharply and were maintained much closer to market levels than is usual in LDCs. In Singapore, real wages were held down for some time despite a growing demand for labor; while not precisely a change in price, this does represent a somewhat unusual policy. And there is no question that all three countries have demonstrated a highly successful record of industrial growth. The problem, however, is that of determining what effects are attributable to the factor price policies mentioned.

In Taiwan, interest rates were raised in the early 1950s and kept high through the 1960s. Industrial output grew rapidly, and the growth rate accelerated throughout this period; the increase in employment began more slowly in the 1950s but gradually accelerated to a high level by the late 1960s (Table1). Although production per employee continued to rise by 7 percent or more per year, it might be said that the maintenance of high interest rates led eventually to factor combinations which provided considerably more employment than would otherwise have occurred. But this would be very hard to prove, given all the other factors influencing these growth rates. Labor intensity also resulted from the export drive focussed on products in which Taiwan's low wages gave it a comparative advantage in world markets.

Table 1. Annual Compound Growth Rates in Industry, Taiwan and South Korea
(percentages)

	1953-58		1958-63		1966-69	
	Output	Employment	Output	Employment	Output	Employment
Taiwan	9.0	1.9	13.1	2.8	20.0	13.2
S. Korea	16.1[a]	5.6[b]	10.0	8.3	28.8	13.7

[a] 1954-58
[b] 1955-58

Source: U. N. Growth of World Industry, various issues.

Korean interest rates were raised only in 1965, so that a short run impact of that change might be easier to find. But the figures in Table I do not suggest a shift toward greater labor intensity in industrial growth following that date, since the growth of employment relative to that in production had been larger in the preceding period. The higher interest rates undoubtedly did much to produce the sharp acceleration of growth in both variables after 1965 by mobilizing savings [see Brown's article in Development Digest, October 1975, pp. 63-78]. And Korean industry,like that in Taiwan, appears to be relatively labor intensive in its methods. But here, too, this resulted in part from a drive to export labor intensive products, and the contribution of high interest rates to factor proportions cannot be isolated.

In Singapore, the annual rates of growth from 1968 to 1971 were as follows: industrial output - 24.0%; industrial employment - 17.7%; real wages - 2.3%. Again, there were many influences at work, and the contribution of wage policy to employment growth may be stated in terms of logic but cannot be measured. In all three cases the merits of more appropriate factor pricing seem to be vindicated by the overall results, the more plausibly because these economies were relatively competitive internally along with their open trade policies. But the attribution of results to specific factor price policies remains ambiguous.

Effects of Differences in Factor Prices Facing Firms of Different Size

Given the difficulties in interpreting the classical cases of policy-induced changes in factor prices and the possibility that these may be in unusually-entrepreneur or skill-rich nations, are there other empirical bases on which to assess the potential benefits of moving towards a more rational factor price configuration? There is a rapidly accumulating body of evidence whose major implication is that differentials in factor prices faced by firms of different sizes have indeed led to alternate methods of production. The higher wages and the lower interest rates typically paid by large firms appear to have resulted in sharp variations in factor proportions among firms within the same industry in a given country. Such cross sectional evidence suggests that a change in factor-price ratios is likely to be effective if combined with competitive pressures in the output market.

A large number of empirical studies have examined differences which exist among firms of different size as measured by number of employees. Of particular interest is the increase in the capital-labor ratio as the size of firm increases for a given industry such as textiles or food processing. This pattern at least partly represents the increase in the use of equipment, tools, and mechanical conveyors in response to increasing wage levels in the larger firms, it being well documented that the wage per worker is highly correlated with firm size. The earliest demonstration of these now conventional findings appeared in analyses of Japanese manufacturing, and the results have been verified for almost all LDCs which have been investigated, the major exception being Taiwan. Table 2 presents fairly typical wage patterns by firm size for the entire manufacturing sector in Mexico in 1965 and Pakistan in 1960. Disaggregation by the two digit classification of industries reveals a similar pattern among firms with similar products.

Table 2. Average Wages and Capital/Labor Ratios by Size of Firm, Mexico and Pakistan

Mexico - 1965			Pakistan - 1960		
Firm Size (number of employees)	Wage Index[a]	Capital per Worker	Firm Size (number of employees)	Wage Index[a]	Capital per Worker[c]
1-5	21	10.5	1-9	58	0.63
6-15	41	31.3	10-19	76	1.96
16-25	55	48.6	20-49	89	2.13
25-50	61	57.5	50-99	96	2.37
51-75	68	62.1	100 and over	100	2.92
76-100	70	63.8			
101-250	78	80.4			
251-500	88	96.2			
over 500	100	104.8			

[a] Index values with 100 for average wage in largest size group.

[b] In thousands of pesos.

[c] In thousands of rupees.

Sources: Saul Trejo, *Industrialization and Employment Growth; Mexico 1960-65*, p. 112 (PhD thesis, Yale University, 1971); Gustav Ranis, *Industrial Efficiency and Economic Growth: A case study of Karachi*, p. 33 (Karachi, Institute of Economic Development, 1961).

Thus, even if companies of all sizes paid the same interest rate and had equal access to imported equipment at the same price, such wage differentials provide presumptive evidence that larger firms devote more effort to economizing on labor than do smaller ones. However, equal access to loan finance and equipment are not good descriptions of reality. Typically, small firms finance their expansion from the saving of the entrepreneur or his relatives and close friends, a group likely to have limited resources. If borrowing outside of this primary group occurs, it is usually from non-bank lenders who charge two to four times the going rate charged by commercial banks. On the other hand, commercial banks and governmentally sponsored industrial development banks usually lend to the larger firms at relatively low interest rates. If interest rates of 10 or 12 percent are charged by these large institutions, smaller firms will typically pay 30 to 40 percent.

The pattern of wage and interest differentials must be assumed to play a major role in the pattern of increasing capital intensity by size of firm, as shown in Table 2 for Pakistan and Mexico. This pattern is also typical within industries, though inevitably some exceptions arise. The smallest companies exhibit very low capital-labor ratios, high average product per unit of capital, and usually a somewhat lower average product of labor. As size increases, the capital-labor ratio and output per worker increase and the output per unit of capital declines. Further analysis typically reveals that the smaller firms are at least as efficient as the larger ones in the sense that if both were to face the same socially relevant factor prices (i. e., the wage rate paid by small firms, and an interest rate which measures the rate of return in small scale industry), the average cost of production in smaller firms would be competitive with that of larger firms, indeed often lower.

While features of production other than differences in factor price ratios might explain some of the observed characteristics by firm size, most studies have concluded that they play a major role. Thus, the examination of capital-labor ratios by firm size provides a rich body of data which confirms the likely responsiveness of entrepreneurs to changes in their cost structure. Such studies have been executed for a sufficiently large number of diverse countries so that one may infer such responsiveness is a fairly universal phenomenon in Asia and Latin America, not limited to countries with a particular history or culture. It characterizes both large and small countries, those which are usually thought to be skill-rich and those which are not. In addition to the analysis of census and survey data, a substantial literature based on interviews confirms the strength of the small scale sector and the skilled entrepreneurship which characterizes many craft firms in LDCs. For example, in Pakistan the rate of return on fixed capital was over 18 percent for firms with 20-49 employees, and less than 12 percent for firms with over 100 employees.

However, it should be noted that neither the presence of abundant entrepreneurship nor many examples of efficient small-scale craft firms have been confirmed in sub-Saharan Africa. The 1972 ILO study of Kenya, despite its emphasis on the potential role of the "informal sector," offers little empirical evidence that craft firms with say 5 to 25 employees exist. Rather, the informal sector consists primarily of self-employed craftsmen such as tailors and carpenters producing products which cannot compete with typical industrial goods, in contrast to the craft firms found in Asia or Latin America. The absence of smaller firms and able entrepreneurs would seem to indicate the need for a different approach to obtaining labor intensive development, as the response to changes in factor prices may not be adequate.

Policy Advice to LDCs

The Need for LDC Government Agreement. The promotion of a labor intensive development process cannot go very far without the active cooperation of the central government. One might envision, for example, technical assistance on an individual basis from private advisers on small business and technology to a target group of companies in an LDC. However, no more than a few such aid recipients will be able to obtain an increasing share of investible funds unless current policies of artificially low interest rates combined with credit rationing by the banks are changed. While small businesses may exhibit high rates of return and could successfully compete for credit in a competitive capital market, their very smallness and paucity of collateral work against them in a rationed market. Similarly, the extensive use of import licenses in the allocation of both capital and intermediate goods works to their disadvantage as it necessitates substantial managerial time, to say nothing of cash payments, to obtain the requisite licenses. In another vein, unless wage-good output is increased and its price level thus kept low, the growth of nominal wages to both small and large firms will produce strong incentives to rely on increasingly capital intensive techniques. In sum, the requisite changes in the allocation of investment funds, import licenses, and the price of wage goods are beyond the influence of private, non-profit organizations or any other industrial extension agencies which work directly with LDC firms.

It is often argued that extension activities will generate a sufficient number of success stories that the demonstration effect will induce an unwilling government to pursue a labor intensive strategy, including a generalized liberalization of the credit and foreign exchange markets. Unfortunately it is unlikely to work. Although a small number of firms may, with intensive advice, identify new products, purchase appropriate equipment and undertake labor intensive low cost production, it is difficult to understand how this can occur on a sufficiently large scale without a prior change in government policies. Who will lend to large numbers of small enterprises at low (institutional) interest rates given the perceived risks, little collateral, and the disproportionately high administrative costs of small loans? Yet if the "demonstration from below" approach is to be persuasive it is necessary for it to occur simultaneously on a large scale in a number of industries and regions, and thus requires substantial amounts of investment funds.

More generally, this "private-non-government" approach is, in a fundamental sense, predicated on a shortage of entrepreneurs. Yet this assumption, for many countries, is counterfactual. The same studies which analyze the characteristics of firms of different sizes also show that large numbers of small firms (say with less than 50 employees) are present in many non-African LDCs in most branches of production, that they have made correct factor choices given the factor prices they face, and that they exhibit high rates of return on their invested capital. These are not the characteristics one would expect if the true bottleneck on expansion of firms using appropriate technology were the absence of entrepreneurial skills. Indeed, they are more suggestive of remarkably adaptive behavior in an economic environment which is skewed to favor large enterprises. There is little reason to doubt that had small businesses been able to obtain access to critical inputs, a faster industrial growth would already have occurred in many countries. My emphasis on the need to change the economic environment does not imply that technical services cannot be beneficial to LDCs, only that by themselves they are unlikely to exert sufficiently large quantitative effects to alter the course of an otherwise capital intensive development policy.

Governments must therefore be convinced of the value of making politically unpopular changes which could assist in the growth of industrial employment. But they may be unaware of the range of choices open to them in pursuing greater employment growth, and of the magnitude of the additional jobs which could be created. Their current policies are not necessarily a result of special interest pressures but rather a response to perceptions which are not accurate descriptions of the reality of their economies. Indeed, many of the most harmful government interventions, undertaken in most cases to effect import-substituting industrialization, were originally advocated by those most concerned with income distribution and unemployment. Important groups in both business and labor are now deriving considerable windfall benefits from the existing system. But there is also extensive evidence of the recognition by many governments of the need to alter current policies if violent change is to be avoided.

Given my premise that changes in technique require government-supported changes in factor prices, it is necessary to follow a two pronged strategy of advice: (1) where governments are insufficiently aware of the employment gains which will result from a change in policy, a demonstration is needed of the aggregate gains; (2) enhancement of the government's ability to achieve the employment goals.

Demonstration of gains from change in policy. An important contribution to generating LDC interest in the possibilities offered by labor intensive techniques can be made by: 1) A systematic cataloging of those economically efficient techniques by industry which have so far been established. This would include, for each process, specific production alternatives such as the type of core production equipment available, alternate peripheral processes, the sources and costs of relevant equipment. 2) Use of the above information in projecting a plan or set of growth objectives which an LDC government would find plausible and desirable. Such a plan may be the official national plan document, but this is not necessary. Projections for an industry can be made of probable total employment growth without altering current production methods, and also with two or more alternative factor ratio regimes using more labor intensive techniques. The saving in capital obtained by producing the planned output in a less capital intensive manner should also be calculated, as this is a major benefit that is insufficiently emphasized in most analyses. The output of some projects which were not included in the original plan, but which now become feasible because of the freed investment resources, could also be calculated.

An illustration of this method is presented in Table 3 using data from a study on the choice of technique in textile weaving. Four methods of producing woven shirting material were identified, each exhibiting considerably different labor requirements and capital costs. Columns 1 and 2 indicate the inputs required to produce an additional 100 million square yards of material, an increase well within the goals of some development plans. Column 3 indicates the capital-labor ratio associated with each type of process. Column 4 shows the amount of investible funds saved by adopting the Lancashire loom, the least capital intensive one, rather than each of the others. Column 5 indicates the additional employment which would be generated by investing the funds so saved in an activity whose capital-labor ratio was no greater than that of the Lancashire loom. Finally, column 6 presents the percentage increase in output which could be generated by investing the saved funds in ad-

Table 3. Aggregate Effects of Alternate Weaving Techniques

Type of Loom	Requirements per 100 million square yards per annum (1) Man-years	(2) Investment	Capital/Labor Ratio (2)/(1) (3)	Gains from using Lancashire Loom		
				Investment Funds Saved (4)	Additional Employment[a] (5)	Increase In Output[a] (6)
Lancashire	2,180	$ 3,582,000	$ 1,645	- - -	- - -	- - -
Battery	1,110	7,163,500	6,454	$ 3,581,500	3,247	100%
Airjet	820	7,877,700	9,665	4,295,700	3,971	120%
Sulzer	510	15,006,300	29,715	11,424,300	8,615	319%

[a] Employment and output from the use of funds saved if these were invested in additional Lancashire looms, or in an activity with the same capital/labor and capital/output ratios.

Source: Underlying data were obtained from Cotton and Allied Textiles (Manchester, The Textile Council, 1969).

ditional weaving capacity. Obviously, other possibilities will be open; the output gain calculated here simply provides some orders of magnitude. Table 4 indicates the overall costs of three of these alternatives under representative conditions.

The potential contribution of systematizing information on available techniques and analyzing their implication for a given LDC is obvious. Existing evidence on the benefits to be derived, industry by industry, assure that these are likely to be enormous and such calculations are likely, at the least, to stimulate governments to consider some of the policies necessary to realize them.

Table 4. Costs of Weaving Shirting Material with Three Methods (dollars per 100 yards)

	Lancashire Loom	Airjet (Elitex)	Sulzer Loom
Space	.198	.093	.152
Power	.385	.385	.291
Weft Waste	.035	.408	.338
Pirning	.472	-	-
Capital Costs[a]	.658	2.167	3.796
Cost of Labor (wage=$832 per year)	1.744	.652	.404
Average Unit Costs	3.493	3.705	4.981

[a] Depreciation and interest charges of 20 percent per annum; includes purchase price plus transport and installation costs equal to 20 percent of the cost of a battery loom.

Source: Cotton and Allied Textiles, Vol. II, p. 83 for lines 1-4. Line 6 calculated from pages 86-90.

Convincing the government of a country of the desirability of changing its economic policies to establish a climate more favorable to labor intensive development is necessary, but may not be sufficient to obtain such development. Although we know that firms of diverse sizes use different techniques, the speed with which changes to appropriate production methods will be made may be accelerated by the presence of good advisory service, especially when there is a demonstrated absence of entrepreneurship.

Technical Assistance to Industry. The services of foreign advisers are likely to be best implemented by those who have been involved in industrial production management over a long period. These managers are likely to have seen the continuous evolution of production methods and are aware that the 1976 method differs considerably from 1956, to say nothing of 1936,and that the latter two were quite viable in their time. Labor intensive methods, particularly in the peripheral processes, characterized American and Western European production until well after World War II. A large pool of westerners exist who have been involved in relevant production management and who could convey both the physical feasibility of labor intensive production as well as some of the organization methods and innovations which surely occurred and increased productivity. By contrast, recent graduate engineers with little production experience are unlikely to be quite so open to alternate production possibilities. They have been exposed to the latest edition of a textbook in food processing and may be unaware that earlier editions showed different equipment. Moreover, most engineering texts and courses concentrate almost exclusively on the technical aspects of production, such as the chemical changes which occur, rather than on costs. Rarely are there discussions of the number of workers used by a machine or the relative costs of different types of equipment. Without exposure to the concepts of costs and the discipline of product prices, engineers are likely to be less open than those with similar training who have had production experience.

In addition to foreign technical assistance, governments should consider their potential for establishing an extension service for small industry within their own ministries, comparable to the advisory service commonly found in agriculture. The problems involved are more complex than those in agricultural extension, and there is less precedent and experience, but the activity merits further exploration.

Tax Policies. Most LDC governments levy some form of business profits tax. The wide variety of tax holidays and accelerated depreciation schemes are directed at reducing these taxes in the hope of generating greater investment, and many of these devices decrease the cost of using capital and thereby encourage capital intensive production methods and should thus be ended. Other ways of reducing the tax burden might be substituted which could encourage the search for labor intensive techniques. For example, reductions in the tax rate applicable to a given level of income could be made contingent on companies presenting a costing of alternate production processes when considering either replacement or expansion. Presentation of detailed cost estimates for at least one more labor intensive process could be made the standard for being placed in a preferred tax category.

Clearly, all firms could not be required to submit such proposals. Presumably, it would be best to start with the largest companies and then move down through the size distribution. An obvious and important potential role for foreign advice would be a catalogue of alternate processes as well as training for LDC administrators, facilitating their ability to establish the accuracy of the alternatives presented. Compliance with tax provisions could be aided by a national extension service, armed with pertinent information.

Strengthening Ability to Finance Loans. One other important policy area is to strengthen the ability of lending institutions to increase the access of small scale, labor intensive firms to capital. Clearly, not all loan applicants can be accomodated. Some screening must take place along with the high rates of interest which should discourage the less efficient firms from applying. Nevertheless, it would be useful to reconsider bank criteria for credit worthiness (possibly in conjunction with selective guarantees), and to make greater efforts to mobilize savings and time deposits. Higher interest rates would make an additional contribution to industrial growth by attracting more savings, as was shown in South Korea.

[Extracted from Attachment D to Proposal for a Program in Appropriate Technology. Submitted by the U. S. Agency for International Development to the U. S. Congress, June 30, 1976.]

Reorganization of Tool and Small Machine Production with Cooperatives in Sri Lanka

D. L. O. Mendis

[The government of Sri Lanka has been establishing a network of cooperative organizations to serve small and medium-sized producers of light engineering products. While encouraging the increase of small village producers using indigenous technology, the localized cooperatives help them to introduce step-by-step technological improvements. At the same time regional cooperatives perform similar services for enterprises using intermediate technology in provincial towns. Extension of similar organization to other industries is planned.]

Sri Lanka's 1972-1976 Five Year Plan presents the general framework for the country's economic development, with sector plans for agriculture and industry. The Industrial Sector Plan stresses the need for a self-reliant approach to development. It recognizes the existence of a traditional sector and a modern sector. In both sectors the development of an indigenous machine-building industry has for a long time been retarded by the unrestricted import of even the simplest types of equipment. Very high priority has now been given to the development of a dispersed small-scale light-engineering industry which will spread technological skills and productive employment in the rural areas. Implicit in this policy is a recognition of the value of an existing traditional technology which is basically an indigenous low-cost technology. This recognition is itself without precedent. A planned and vigorous pursuit of the progressive improvement of this indigenous technology will serve the objectives of rapid economic development.

Mr. Mendis is Deputy Director (Techniques)
in the Ministry of Planning and Economic
Affairs in Colombo, Sri Lanka

In both the public and the private sectors in Sri Lanka there already is a considerable investment in modern technology which is comparatively productive and capital-intensive. The progressive development of indigenous technology in the traditional sector has now been planned so as to gain from linkages with the high technology in the modern sector. This contrasts with earlier policies when new industrial technologies were introduced with little regard to existing low-cost producers whose development was thereby retarded. Examples of such mistakes include the introduction of modern power-looms which competed with existing handlooms, the development of mass-produced aluminum household goods which destroyed the traditional pottery industry, the setting-up of a State Hardware Corporation to manufacture various agricultural tools and implements and building materials which were already being made by indigenous industries, or the production of soap by the local subsidiary of a multinational corporation which almost eliminated the small-scale soap makers. Furthermore, all this modern equipment has represented a costly use of foreign exchange, a resource which has been in short supply in Sri Lanka for the past fifteen years.

The new approach is to establish cooperative organizations at two levels: at the local level, cooperatives serve the small producers using indigenous methods, and help to improve their skills and equipment; at the regional level, cooperatives serve medium-sized establishments with intermediate technology.

The Local Level: Dispersed Production Cooperatives

The chief vehicle for implementing the new development policy based on low-cost technology and the improvement of indigenous industrial capabilities was the Divisional Development Council (DDC). [The Division is a unit of local government.] The Council's projects are all in the form of cooperatives. One particular type is the Dispersed Production Cooperative. This is an organization of individual entrepreneurs and workers in a given industry in a particular region or Division. This type of organization has the following features.

1) Cooperative members continue to work in their village workshops. The individual worker may engage in productive work at any time of the day or night that suits him; he may be assisted by members of his family. The training of new workers takes place on a person-to-person basis in a comparatively small work-place.

2) The cooperative arranges for the supply of inputs and takes care of the marketing. Its members can devote most of their time to actual production, and they cannot be exploited by middlemen.

3) Financial assistance for an owner to improve his work-place, or for an employee to start his own business, is more readily available from the People's Bank through the cooperative organization than it would be for small independent individuals.

4) The individual owner has every incentive to develop his work-place and improve his technology and his productivity; and an employee has the prospect of setting up his own work-place one day with the technical and financial assistance of the cooperative.

5) Because of his membership in the cooperative, the individual producer can tide over market fluctuations more easily than if he were alone.

The Regional Level: Medium-Scale Industrial Cooperatives

Dispersed production cooperatives of village blacksmiths were first set up on the basis of one for each Division. By August 1974 more than 100 of these Light Engineering Industrial Cooperatives, as they are called, had been established in a total of 158 Divisions all over the island. At the next higher level of technology, cooperatives were set up for the owners and skilled workers of the small workshops which are very common in provincial towns. These are called Medium-Scale Industrial Cooperatives, and it was proposed to have such organization for each of the 22 administrative Districts in the island. Later it was decided to also have Medium-Scale Industrial Cooperatives in each of the Divisions in the Colombo District. By August 1974, seven of these Medium-Scale Industrial Cooperatives had been established. A Union of Light Engineering Industrial Cooperatives was also formed as the national apex organization for the light-engineering industry.

The Union, as the representative body of the organized light engineering industry in Sri Lanka, has broken into some new areas of activity, of which ship-breaking (for salvage of materials) is the most noteworthy. The Union has also purchased a modern production factory which manufactures motor and tractor spare parts, weighing machines and other products.

Through the organization of Light Engineering Industrial Cooperatives in the rural areas, the traditional low-cost technology of the village blacksmith has been made more productive, and the quality of production was improved. The cooperatives organized the supply of raw materials including scrap iron and steel, charcoal and small hand tools such as files. They also undertook the sale of finished products through a commercial center. Orders for various tools and implements were obtained in advance from government organizations as well as from the plantation sector, an important consumer of such hardware in Sri Lanka.

Quality Control. With the organization of supplies and wider markets for the village blacksmiths, a higher quality of product was required to meet market demands. Quality control is ensured by a combination of traditional and modern methods. Traditionally, the village blacksmith made and sold implements to the farmer on the basis of a person-to-person guarantee. This has been formalized in the cooperatives by giving each member an identification number that is stamped on every product, which is then guaranteed for one month from the date of purchase. If a defective item is brought back by the purchaser, the cooperative replaces it and returns the defective item to the maker. If the defect appears to merit special attention, the problem is referred to an outside consultant. This consultancy service is provided by metallurgists in the University's Faculty of Engineering and the Sri Lanka Institute of Scientific and Industrial Research.

The Pricing Mechanism. Since the blacksmith obtains his raw materials from the cooperative, he is liberated from the clutches of middlemen who had previously supplied the inputs and purchased his products, and generally retained an unconscionable profit. The producer now obtains much more of the profit. In order to give a fair deal to the consumer, a Price-Determining Committee has been set up in each cooperative. Usually this committee consists of three blacksmiths representing the producers and three local farmers representing the consumers, with an official of the Planning Ministry as the chairman. The committee examines the amount of raw materials and labor necessary for manufacturing the products on the basis of the blacksmith's low-cost technology, and arrives at the prime cost of production. A reasonable profit margin is allotted to the producer and a further markup of between 10 and 15 percent is allotted to the cooperative in setting the selling price to the consumer. Profits accumulated in the cooperative will in the future be used for the progressive development of technology.

Investment and Employment. With this type of organization, productivity has been considerably improved. Today a master blacksmith and two assistants can produce more than 2,000 rupees (about $250) worth of digging forks per month using the simple technology of the village smithy, which represents a total capital investment of some 5,000 rupees (about $630) at today's prices. New employment has been generated in two different ways. Firstly the master blacksmith takes on more helpers to increase his production. Secondly, skilled blacksmiths who are working as helpers are able to set up their own workplaces. The cooperative encourages this type of development with individual loans from the People's Bank. Some cooperatives have more than doubled their membership through this process in the last three years.

The Role of the Technical Centers

Once a Divisional cooperative has been established and has started to function steps have to be taken to set up a technical center. This center will be equipped with tools which are not generally available in the small work-places of the cooperative's members, such as a power hammer and power saw for reducing large scrap into the smaller billets which are issued to members. It will also include a lathe, a drilling machine, and both electric arc and gas welding equipment. This equipment will be used for certain specialized operations like the production of some component parts for small agricultural implements. An assembly unit will also be set up in the technical center to make small agricultural machines.

The progressive development of technology in individual work-places has been planned through the technical centers. At the village level a blacksmith is usually equipped with a hearth and a pair of bellows, an anvil, a number of sledge hammers, a vice, several pairs of tongs which he usually makes himself, a few files and sometimes a grinding wheel, and finally a manually-operated drill. With this equipment he can make a wide variety of tools and implements. In general he was dependent on traders for the supply of raw materials such as scrap iron, steel and fuel (usually charcoal). The trader also sold him the tools of his trade that needed periodic replacement like the files and the grinding wheels. Likewise the blacksmith was dependent upon middlemen for the sale of his products. As a result, he invariably functioned at a low economic level and did not have the capacity to generate sufficient savings to develop his technology.

With the organization of industrial cooperatives, the village blacksmith is now able to put aside a certain percentage of his earnings and invest it in the development of his technology. The progressive development of technology can be described as a step-by-step improvement of the tools of his trade. This improvement will in the first stage allow him to use the physical energy available to him in a more productive way. Thereafter, it will enable him to add mechanical energy to his production process. He will be able to pay for mechanical power with his own savings and with credit facilities made available through the cooperative. Next, using mechanical power, he will be able to manufacture products on a more systematic basis, and in larger quantities, and go into a production-line type of manufacturing if regular orders for his new products are forthcoming.

In practice, when a blacksmith produces more and increases his savings, he will probably have priorities other than the improvement of his technology. Settling old debts, improving his house, and purchasing movable property like furniture and jewellery generally take precedence over improvements in the work-place. But a few individuals will turn to investment, and the first blacksmith who takes steps to improve his technology is a pioneer whose example is watched closely by the others before they decide to follow suit. The interest of the cooperative is therefore to encourage the success of this, and the consultancy service available through the technical center must be used to maximum effect at this stage.

The technology of the village smithy can be systematically improved in a number of ways: (a) by introducing a more efficient hand-operated blower to replace the bellows; (b) by the better conservation of heat in the hearth, and the use of waste heat for tempering and perhaps for annealing; (c) by introducing a mechanical finishing hammer (manually operated in the initial stage) to achieve a better finish in a more economical way; (d) by using grinding wheels to save on filing; (e) by introducing mechanical power which may be used initially for the mechanical finishing hammer, the blower, the grinding and finishing wheels and a drill; power may be used later to operate a simple lathe and a power hammer.

It is preferable to introduce mechanical power only when the blacksmith already has a certain amount of equipment, such as a mechanical finishing hammer, a blower, and a grinding and finishing wheel. At this stage, mechanization is an economic proposition. Mechanical power can also be used for other types of equipment, for instance, for the simple home-made hand-operated lathe which can be found in almost every smithy and which is used to turn out wooden handles for knives and other implements. It has been found that such a planned step-by-step development of technology is well within the bounds of reality once the productive capacity of the village craftsman has been liberated by the organization of cooperative, that is when the middleman has been eliminated and regular markets have been made available. At a later stage it is expected that the village blacksmith will be able to purchase and use more sophisticated equipment, including welding plant and machine shop plant. He will then have qualified for membership in the Medium-Scale Industrial Cooperative at the District level.

Innovation in the Medium Scale Industrial Cooperative

Medium Scale Industrial Cooperatives were set up to harness the un-utilized and under-utilized production capacities in workshops dispersed all over the island. These include small machine shops, repair garages and foundries. It has been possible to produce small machines such as two-wheeled tractors by farming out the manufacture of component parts to members of these organizations. This particular project has been tried out in no less than seven cooperatives which have all successfully manufactured and tested prototype two wheeled tractors (the engine, the chain and the main bearings of these machines are imported). This project was launched in the teeth of opposition from those who believe that the only way to make a two-wheeled tractor in

Sri Lanka is to set up a joint-venture with a foreign firm. The success of the project is therefore to be measured not merely in terms of the number of tractors manufactured in this way, but in terms of the number of individual entrepreneurs and skilled workers who have been given an opportunity to use their talents to create a commercially viable product. This is a very important element in achieving a self-reliant attitude to development.

At the beginning of this project the Ministry of Planning set up ad hoc committees of individuals who were known to be interested in it in order to launch the manufacture of this machine through the industrial cooperatives. This group of individuals brought in their varied expertise and gave the necessary initiative for developing the prototypes. This method has been quite successful. Prototypes have also been manufactured in public sector organizations under the direction of these ad hoc committees. It is expected that some of these public sector institutions will also undertake batch production of these machines in the future.

The first priority has been given to the development of the two-wheeled tractor, but the need for local manufacture of water pumps has been repeatedly emphasized by the members of several cooperatives. One such pump has been developed locally; it is mounted on the frame of the two-wheeled tractor and driven by the same power unit. Other machines which have been developed in small workshops as a result of the organization of the industrial cooperatives include a bicycle and a water pump. Both are now in batch production. Several prototypes of single cylinder air-cooled internal combustion engines have also been made but none of them have yet been taken up for batch production.

The reorganization of Sri Lanka's light engineering industry by the Ministry of Planning and Economic Affairs under the Divisional Development Council's program has met with such success that the same approach is being used for other industrial sectors. Steps are being taken to organize village potters who have been unfortunately discriminated against: bureaucratic ignorance has promoted other industries that tend to suppress the traditional pottery industry. Similar work in organizing the traditional textile industry can be expected in the future.

[Extracted from Appropriate Technology: Problems and Promises, pp. 206-12. Paris, France; Development Center, Organization for Economic Cooperation and Development, 1976.]

Entrepreneurship and the Promotion of New Low-Cost Technology

Nicolas Jequier

[In September, 1974, the OECD (Organization for Economic Cooperation and Development) sponsored a conference of some forty practitioners of the promotion of low-cost technology for developing countries, about equally divided between specialists from developing countries and those from Europe and North America. A major conclusion of participants, expressed in this synthesis of conference results, was that the individual entrepreneur has a vital and indispensable role in the promotion of new low-cost technology.]

The work done by the various intermediate technology groups shows that it is technically possible to develop new products, production processes and services which are better adapted to the requirements of the people in the developing countries than those offered by the capital intensive high technology industries. Perhaps the most important contribution of these groups is to show that there are alternative approaches, and that the technical and human resources of the most underprivileged segments of the population can be mobilized much more effectively than they are now. Developing new technologies to meet what seems to be very real needs is however but one aspect of the innovation mechanism. Technology is a process, not an end in itself, and it must somehow be translated into new products and new services if it is to be of any use. Products must be manufactured and sold; and this can only be done by an industrial firm or, if the market is very small, by individual craftsmen.

Mr. Jequier is Administrator, Industrialization and Technology Program, OECD Development Center, Paris, France.

Individual entrepreneurs versus collective organizations

One of the most striking conclusions emerging from the September 1974 meeting was the strong emphasis placed on the role of the individual entrepreneur, and a generalized skepticism about the effectiveness of government agencies and cooperative organizations in promoting low-cost innovations. Another conclusion, stressed time and again, was that intermediate technology, if it is to succeed, must be economically, socially and technically competitive.

Stressing the role of the individual entrepreneur may appear like a return to old fashioned economics, and an implicit indictment of the organizational forms and ideologies which have increasingly governed the development effort of many countries in the last twenty years. On the other hand, it might be viewed simply as a reflection of the pragmatism and realism of the intermediate technology proponents. There is no doubt a certain cultural and social affinity between the philosophy of intermediate technology and the attitudes of the small entrepreneur, and this may account, at least in part and somewhat subconsciously, for the major emphasis given by many low-cost technology practitioners to the role of the individual entrepreneur. The economic and social life of a nation is immensely complex, and even the best policy-makers cannot hope to organize it in one single universal and rational way. What the various experiences presented at the conference do seem to suggest is that, as far as intermediate technology is concerned, some indications are available as to how not to proceed.

Among the many unsuitable approaches, the first to stand out is that of the cooperative movement. Many countries, for reasons which are essentially ideological and political, have tried to base at least part of their development effort on cooperatives, and in Tanzania for instance, this is today the main form of organization of the nation's economic and social life. The difficulties encountered by the cooperative movement in countries like India or Sri Lanka seem to be due to two types of reasons. The first is the high degree of administrative and technical skills required to operate such an organization. As far as administration and management is concerned, the cooperative network with all the services that must be coordinated is in fact a "high technology" enterprise, in the same way that the small family firm or workshop is a "low technology" organization. If all the members of the cooperative are to take an effective part in its activities, they need to have a relatively high educational level; and the central group of people who serve as its managers must be skilled administrators and, equally important, they need to be highly motivated.

The second problem touches upon the very ways in which cooperatives are formed. If we look at the cooperatives in Western countries which, judging from several decades of experience, have been the most successful - for instance in the Scandinavian countries, in Switzerland or in Israel - one of the main reasons for success is that they were created by the people whom they benefit. At the origin of a successful cooperative, there is not only a community of people sharing the same values and interests, but also an institutional entrepreneur and social missionary. Yet despite the crucially important part played by such innovators, the success of a cooperative depends very much upon the involvement of the whole community.

The gradual building up of a cooperative network is a long process, and quite understandably, many developing countries have tried to accelerate the process by training administrative staff and establishing new cooperatives by government decree. These cooperatives, created by the government rather than by the communities they are intended to serve, are usually faced with tremendous administrative difficulties and, as a result of their political links with the government, tend to be viewed with great distrust by the population, especially in the rural areas. Large financial subsidies do not make them socially more acceptable. In fact, when they do have a lot of public money at their disposal, the members will almost inevitably interpret this as a private grant for their own personal use, or as a fair compensation for the exactions of the government tax collector.

This is not to say that cooperatives cannot work as a matter of principle. There are in fact examples of successful cooperatives in a number of developing countries, most prominently in agriculture. What the experiences of the practitioners in intermediate technology seem to suggest is that, in general, the cooperative form of organization is not the one best suited to the development and large scale diffusion of this type of industrial technology. For example, a very efficient small-scale means of producing crystal sugar was presented in India simultaneously to private entrepreneurs and farmer cooperatives created to use it. Four of the eight cooperative plants started between 1958 and 1962 ended in bankruptcy, despite much assistance; and only six more opened during 1962-74. By contrast, individuals had created 1200 new units in less than 14 years, and now produce almost 20 percent of India's crystal sugar.

The role of government

Large public or governmental organizations tend to be beset by bureaucratic inefficiencies and administrative weaknesses, and there are some justified doubts as to their ability to promote in a direct way the development of intermediate technology. Government agencies do nevertheless have a role to play - perhaps not as industrial entrepreneurs and innovators. But what happens is that the initiative of such people is often systematically stifled by the government bureaucracy, the banking and credit system, the marketing and distribution organizations, and last but not least the social pressures against innovation and change. The guarantees required by public credit institutions for instance are such that a new entrepreneur has practically no chance of obtaining any financial aid. Import regulations and foreign exchange restrictions make it virtually impossible for him to obtain from abroad the equipment he needs either to manufacture goods or to develop his own technology; and when he does happen to have money, the priorities of the national economic plan do not allow him to invest it as he sees fit and he must spend vast amounts of time and energy trying to get approval for his projects. From the entrepreneur's point of view, it therefore makes much more sense not to engage in industrial activities and to devote his energies to socially less productive and personally more rewarding activities like trading or real estate.

One of the tragic paradoxes of this situation is that while governments on the one side are trying very hard, and often at great social and financial expense, to build up new consumer goods industries, the institutional obstacles to entrepreneurship on the other, coupled with the competition from these highly subsidized industries, is stifling the creation of new small firms and progressively destroying the economic and social bases of the local handicrafts industry. The example of the shoe manufacturing industry in one Middle Eastern country is unfortunately very typical: the new factory imported from Western Europe at great expense flooded the market with cheap plastic shoes and ruined thousands of small shoemakers who are now unemployed. Many developing countries are spending vast sums of money to import foreign technology, but at the same time these imports are helping to destroy the existing technological system in a large number of sectors. Clearly the process of creating and diffusing new technology is inseparable from the decay and disappearance of older technologies and obsolete knowledge, and a complete preservation of the past can only be achieved at the cost of complete stagnation. But in many countries this process of destruction of traditional technology is artificially accelerated by large-scale industrialization and, what is of much greater consequence in the long run, it is destroying both socially and morally the very class of people who have the technical and inventive ability which is so important in the process of development.

This is not to say that the actions of government are always harmful, or that large scale industrialization as such is an evil. But governments could do much more than they have by helping to create a more favorable climate for the development of entrepreneurship. Before even considering what positive measures might be taken, it would be useful to start by dismantling at least some of the institutional obstacles to entrepreneurship. These obstacles are innumerable, and in most cases relatively easy to identify: it is only necessary to ask those innovators who have succeeded in overcoming them. Such surveys have seldom been conducted; and if they were followed up by specific remedies, they would probably be much more useful and effective than the somewhat grandiose schemes for technical education, management training or information services established by government authorities, often on the advice and with the help of foreign aid agencies.

What such surveys would probably show is that the disincentives or obstacles to entrepreneurship are rather similar from one developing country to another. Among the most conspicuous, one could mention for instance the taxation system, which is often very favorable to large enterprises - including foreign firms - and overly harsh on the small company. Import regulations are another case in point. To give a typical example: in one of the large tropical African countries, a small entrepreneur had decided to start manufacturing aspirin. He had managed to buy the necessary machines and to import in bulk the raw materials he needed. But the refusal of the Ministry of Trade to reduce the enormous duties on small glass bottles, coupled with the duty free imports of aspirin in tubes from Germany, caused the new enterprise to close its doors and ruined the man who had started it . One may of course argue that he should have known about the structure of import duties and import regulations before starting. In this case however - and this is not untypical - regulations are constantly changing, and the entrepreneur cannot count on the minimum of stability which is required for building up new industries.

The social patterns of entrepreneurship

Creating a more favorable climate for entrepreneurship can be greatly facilitated by a number of relatively simple measures. There are however a number of social factors which cannot easily be changed. Among the most sensitive from a political point of view is the fact that certain types of entrepreneurship are often associated with certain ethnic and linguistic groups. In Cameroon for instance, some 80 percent of the trade in basic products like oil and soap is in the hands of the Bamileke. And in Kenya, the data show that 93 percent of new companies registered between 1946 and 1963 belonged either to European or Indian settlers, and that the total capital of the African owned companies amounted to less than 1 percent of these new firms. In Thailand, a large proportion of the entrepreneurs who have gone into the tractor rental business for the green revolution happen to be Chinese. In Zaire, the Balubas represent some 10 percent of the population, but reportedly some 70 percent of the university graduates belong to that ethnic group.

Hundreds of similar examples can be found elsewhere. It should however be stressed that the social tensions which arise from the ethnic or religious affiliations of a country' s entrepreneurs are not specific to the developing nations: the history of the Jews in Europe or of the Protestant minorities in Catholic countries bears this out very clearly. The promotion of entrepreneurship, and in particular of entrepreneurship in intermediate technology, cannot leave out the cultural, ethnic and religious factors. One interesting way to deal with this problem is that of the INADES in the Ivory Coast. In that country most of the tradesmen are foreigners - Lebanese, European or Malian;

and the INADES has attempted through its training programs in the commercial field to build up a class of Ivorian merchants and shopkeepers.

If ethnic or religious affiliations are an important determinant in the patterns of entrepreneurship in a country, the same is also true of a society's system of values or its social traditions, and such things take time to change. That entrepreneurship is good for the economy is one thing, but its social acceptability is another. The motivations of the man who starts up a new enterprise are very complex, and he will tend to go into activities which are approved by the majority and which give him both financial rewards and social prestige. These activites are not necessarily those which contribute most to increasing the gross national product or to developing the country's industrial base. As P. D. Malgavkar has observed in his study of the techno-entrepreneurs of the Poona area in India, one of the most positive results of their work has been to bring about a gradual change in values and to make industrial activities socially more acceptable and more prestigious than they were a few years ago, and this in turn will probably motivate other industrial entrepreneurs to start up new firms.

The growing interest of many governments and aid-giving agencies in low-cost technology can contribute not only to its development and widespread diffusion but also, and this is in some ways more important, to giving the social and cultural prestige which it now lacks. There are clear indications that intermediate technology is now moving from a somewhat marginal position in development policy to a much more central role. This process of institutionalization means that more money will be available for new experiments. Needless to say, there are certain risks, and one of the main ones is that of bureaucratization. However one should not overlook the major social and psychological importance of this new trend. As long as governments and aid-giving agencies were concerned almost exclusively with large-scale projects and modern industries, it required an enormous amount of independence of mind on the part of the intermediate technology proponents and the few local entrepreneurs in the developing countries to stand up against what everyone else, including the experts, thought was right. Marginality is not of course a deterrent to the true missionary, quite the contrary; but in this case it meant that intermediate technology had little chance of involving the millions of people who form the silent majority, and who stand most to benefit from it. The active interest of national governments and foreign aid donors in low-cost technology could reverse this sitution by legitimizing the efforts of local entrepreneurs and innovators in this field, and by providing powerful incentives to those who might otherwise have gone into socially less productive activities.

Socially and politically, intermediate technology is not neutral. In fact, one of the basic assumptions of its proponents is that it should be aimed primarily at the poorest segments of the population, most of whom live in the rural areas. How this can be done most effectively is not entirely clear. One of the means is to try gradually, through education, extension services, financial assistance and social rehabilitation to identify and stimulate the entrepreneurial and innovative forces which exist in all communities but which have been weakened and repressed by the existing economic and social system. What must not be overlooked however is the fact that these entrepreneurial forces, once released, will not focus exclusively on building up small industries and developing new technologies, but will also in many cases address themselves to social reforms and political change. The social background and the psychological dispositions which make a man a good potential entrepreneur are no guarantee that he will become an industrial entrepreneur and thereby contribute to increasing the gross national product. He may just as well become a political entrepreneur and a social revolutionary. This is not necessarily negative: it may in fact be one of the most effective means of stimulating a real development process in the most underprivileged segments of the population.

The competitiveness of low-cost technology

One of the most important factors in the diffusion of intermediate technology is its competitiveness compared to other technologies and other ways of doing things. A technology will not be adopted by the producers or the consumer because it is new - quite the contrary. Novelty as such is more often an obstacle than an incentive to its diffusion, especially in the rural areas. What is important is that it should be technically and economically more advantageous than both the existing traditional technologies and the modern technologies embodied in the products of large-scale industry. As several participants of the meeting have clearly pointed out, intermediate technology must be economically, socially and technically competitive with other types of technology, modern or traditional. It must also be commercially viable and capable of producing a surplus for those people who will be using it.

Two big difficulties arise here. The first is that the range of intermediate technologies which can be developed is considerably wider than the number of those which meet these basic conditions of competitiveness. One can wonder for instance whether the rainwater collection system presently being developed by the IRFED for African countries is really competitive. Their plastic sheets covering the traditional roof may well be technically appropriate, but one of the alternative solutions, namely the tin roof, is not only technically simpler but socially much more prestigious. The tin roof, quite apart from its practical convenience, is one of the most conspicuous signs of affluence and a top priority in a family's investments.

The second difficulty is that it is usually very delicate to evaluate the competitiveness of intermediate technology. Part of the problem stems from the fact that the concept of "competitiveness" or "efficiency" covers three very different notions. The first is what might be called the technical or engineering efficiency of a new product or a new way of doing things. The second is its economic viability, and the third its social and cultural acceptability to those who must use it. On the basis of these three criteria, intermediate technology must then be compared with the traditional technologies and with the large-scale technologies of modern industry. This gives us six criteria of competitiveness which can be presented in the form of a simple matrix as follows:

Table 1. Criteria of competitiveness of appropriate technology

	Competitiveness vis-à-vis traditional technologies	Competitiveness vis-à-vis modern technologies
Engineering efficiency		
Economic viability		
Social acceptability		

In theory, the intermediate technology which stands the greatest chance of success on the market is the one which, on the basis of these criteria, happens to be the most competitive or the most efficient. In reality things are considerably more complex, and the successful innovator often has to rely more on his own experience and his personal hunches than on rational economic and technical analyses. This set of criteria does however suggest three important points. The first is that social or cultural acceptability is often a major factor in the success or failure of an innovation. Because it is so subjective and ill-defined, there is an obvious temptation to favor the more rational criteria of engineering efficiency or economic viability. The second point is that intermediate technology has to compete not only against the existing traditional technologies, but also against the whole technological system of modern industry. The latter is in many cases remarkably efficient, which suggests that intermediate technology is in a number of sectors totally inadequate.

The third point is the dynamic nature of the technological system. The criteria indicated here can give some idea of the competitiveness of intermediate technology today. As time goes by, however, they can change very substantially. What is socially acceptable today may no longer be so tomorrow. Modern technology is in a process of constant change, and even the basic economic assumptions (labor costs, price of raw materials, import duties, transport costs) can be radically modified within a period of a few years. Many entrepreneurs sense this very clearly, and it is interesting to observe that in a number of cases their technological choices anticipate by a few years what is likely to happen in their country. Industrial wages for instance may be very low today, but most private entrepreneurs expect them to rise, and this, coupled with the development of trade-unionism, almost inevitably brings them to choose more capital intensive types of technology. This was the case for instance in the Bolivian cigarette industry, the Cameroonian soap industry, or the Zairian copper mines.

What the shifting nature of these criteria suggests is that appropriate technology, if it is to succeed, must not only be competitive today, economically, technically and culturally, with existing technologies: it must also have what might be called an evolutionary capacity. The problem in other terms is not simply to develop new technologies to meet an immediate need, but to build up an innovative capability, or innovation system. What international technology transfers can do is to introduce new ideas, new forms of knowledge and new ways of doing things. But what they cannot do is to help build up within the importing country the entrepreneurial and innovative basis which in the long run will ensure the widespread diffusion of low-cost technology. In fact, there are many indications that such transfers have the opposite effect, and contribute in some ways to killing off the innovative forces which exist. Almost all developing countries today are politically independent, and many of them are trying to gain a certain amount of economic independence. But what is the most difficult to achieve is a certain form of technological independence. Clearly, in the scientific and technologica field no country can be completely independent, no more than it can be in the economic or the political field. Independence is a question of degree; but a certain form of technological self-determination is necessary in the development process. No country in history, not even Japan, has ever managed to develop exclusively on the basis of imported technology. This is the task of the indigenous entrepreneur.

[Extracted from Chapter 5 of Appropriate Technology: Problems and Promises, edited by Nicolas Jequier. Paris, France: Development Center of the Organization for Economic Cooperation and Development, 1976.]